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(56) Documents cited None
(58) Field of search H4F

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(54) **Compatible high definition television system**

(57) A high definition camera 400 produces high definition signals which can be sent directly to an appropriate high definition monitor 1012 or alternatively, in the compatible system can be low passed filtered 1010 to produce a low definition signal compatible with a normal standard monitor 710. To reduce bandwidth the low definition signal is subtracted 1014 from the high definition signal to produce difference signals Δ which may be inserted into the blanking intervals of a normal T.V. signal, or transmitted separately as shown. In high definition monitor the difference signals are added to the low definition signals 1018 to reconstitute the high definition signals. Production of the difference signals may be inhibited where there is motion in the image.

The high definition signals are produced by selecting pixels alternatively from adjacent line scans either by a sinuous scan or by selecting pixels from a store.

The specification discloses systems with and without bandwidth reduction, cameras, monitors, and analogue and digital signal processing techniques.

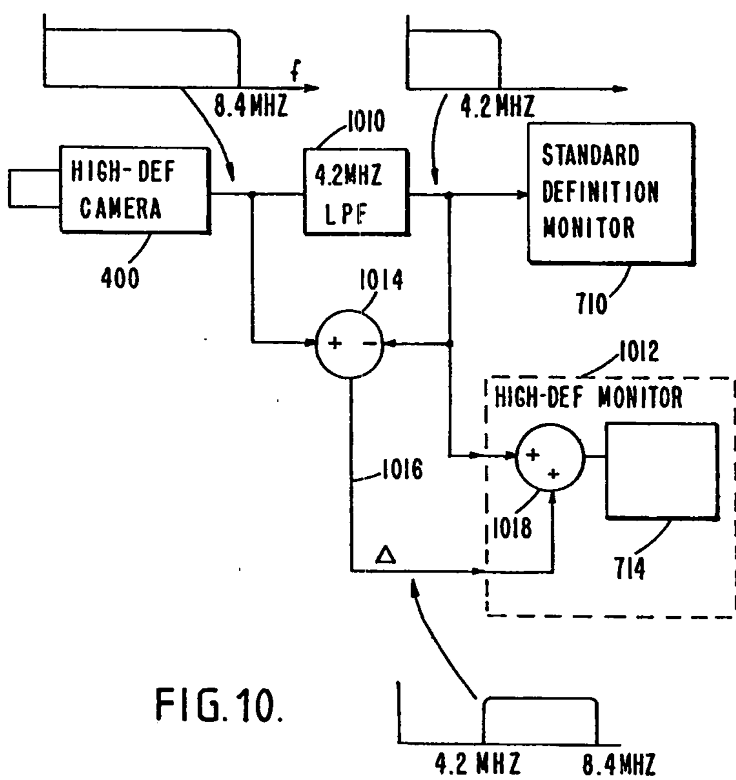


FIG.10.

GB 2 115 641 A

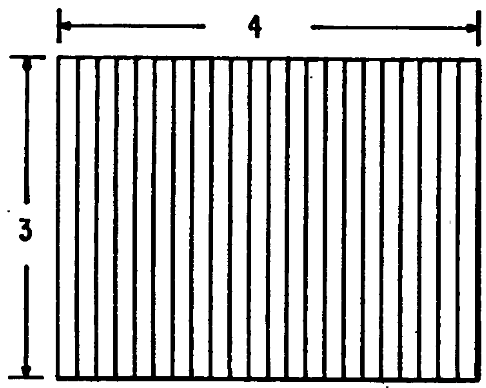


FIG.1.

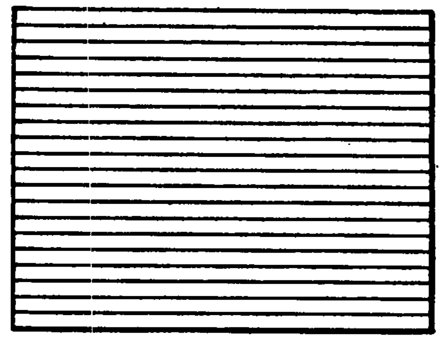


FIG.2.

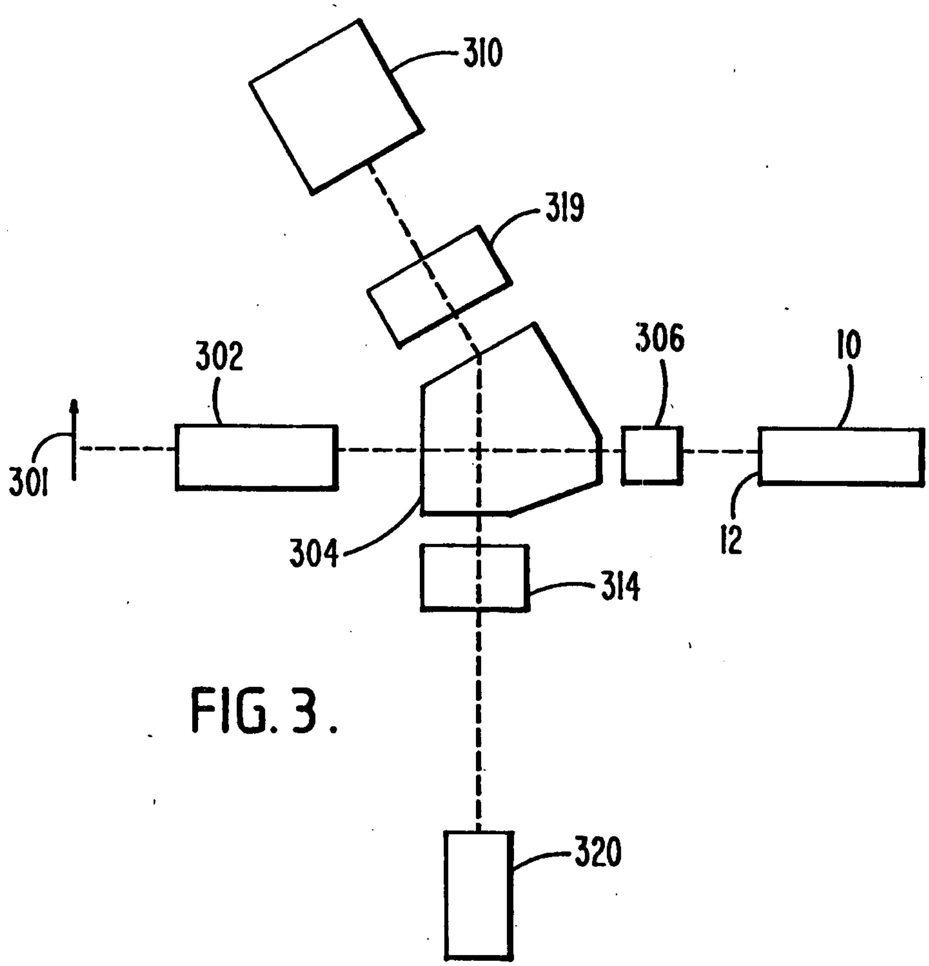


FIG.3.

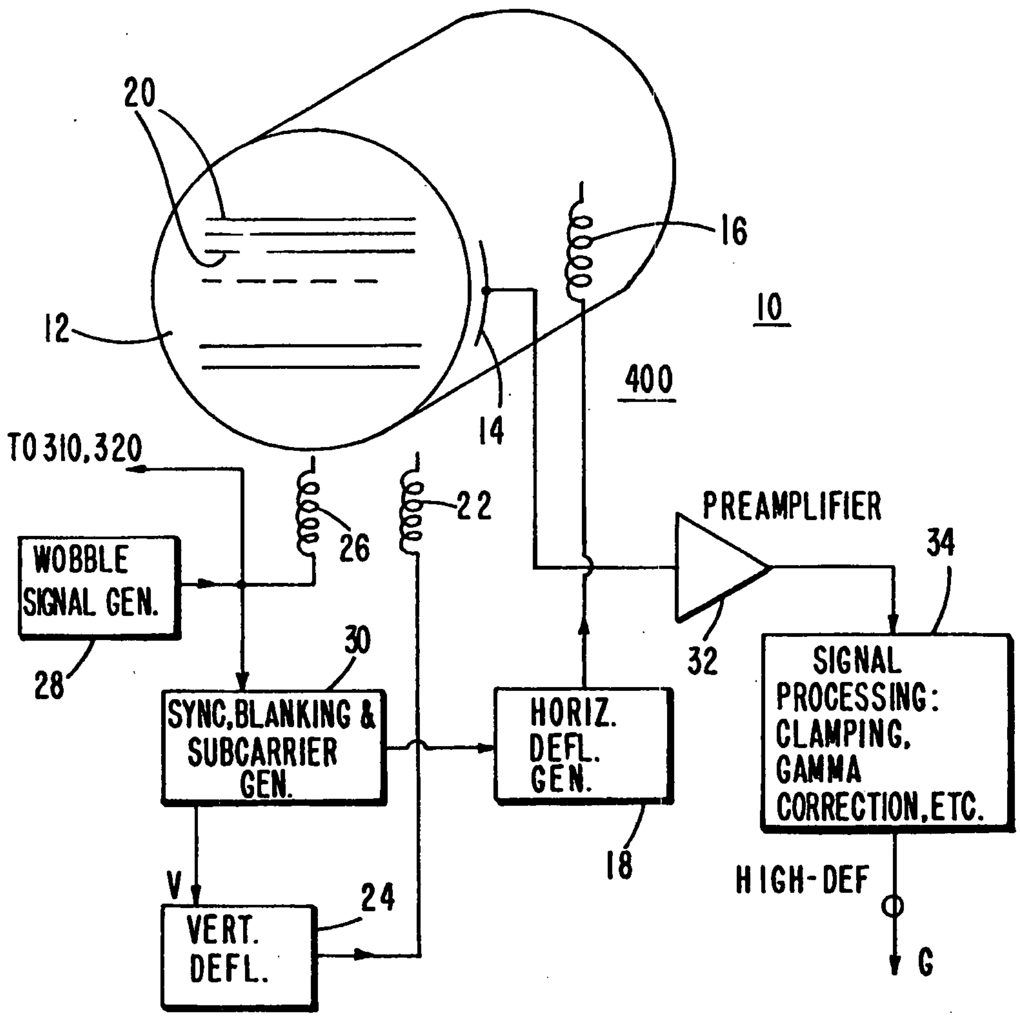
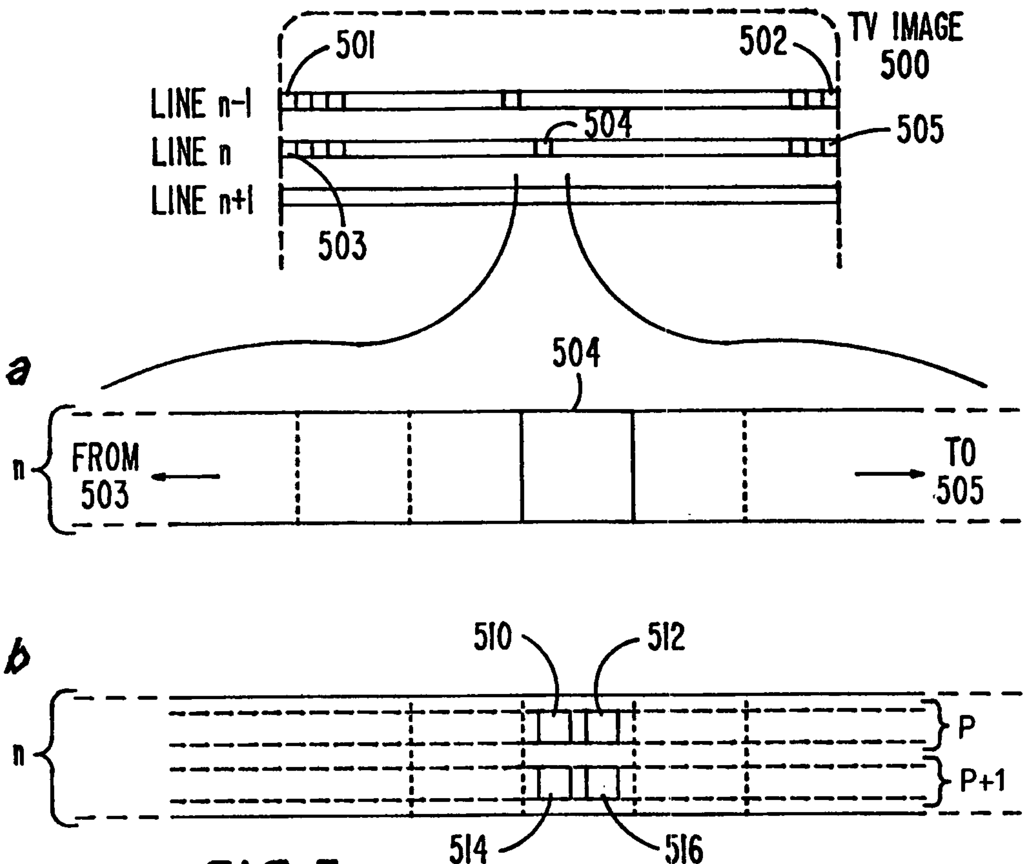
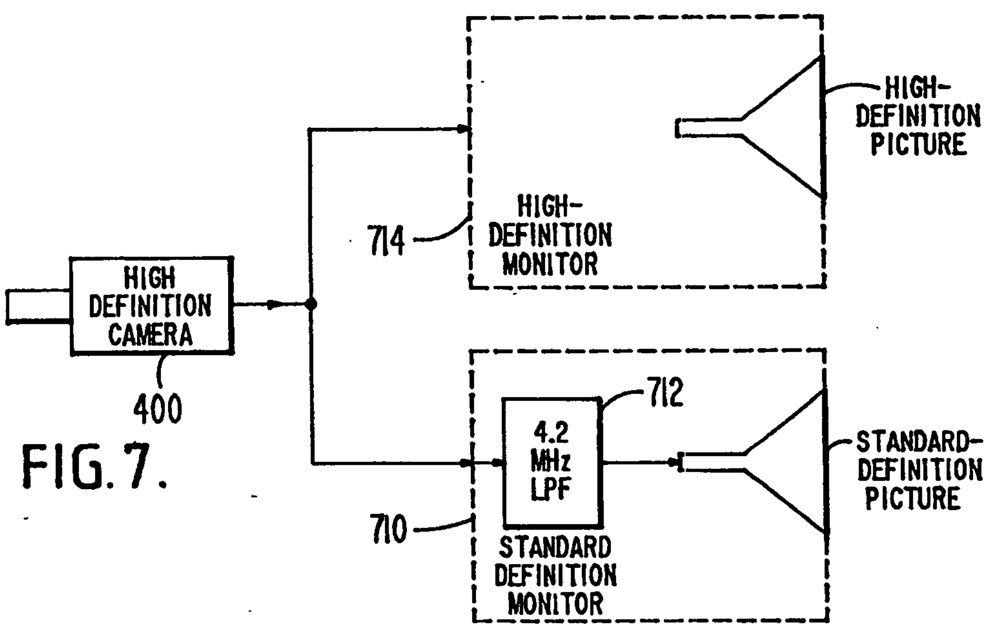

20
16
12
10
400
14
TO 310,320
22
PREAMPLIFIER
26
WOBBLE
SIGNAL GEN.
34
28
30
32
SYNC,BLANKING &
SUBCARRIER
GEN.
HORIZ.
DEFL.
GEN.
SIGNAL
PROCESSING:
CLAMPING,
GAMMA
CORRECTION, ETC.
V
24
18
HIGH-DEF
VERT.
DEFL.
G

FIG. 4.



TV IMAGE
500
501
502
LINE n-1
LINE n
LINE n+1
504
505
503
a
504
n
FROM
503
TO
505
b
510
512
n
P
P+1
514
516

FIG.5.



HIGH-
DEFINITION
PICTURE
714
HIGH-
DEFINITION
MONITOR
HIGH
DEFINITION
CAMERA
400
712
4.2
MHz
LPF
STANDARD-
DEFINITION
PICTURE
710
STANDARD
DEFINITION
MONITOR

FIG.7.

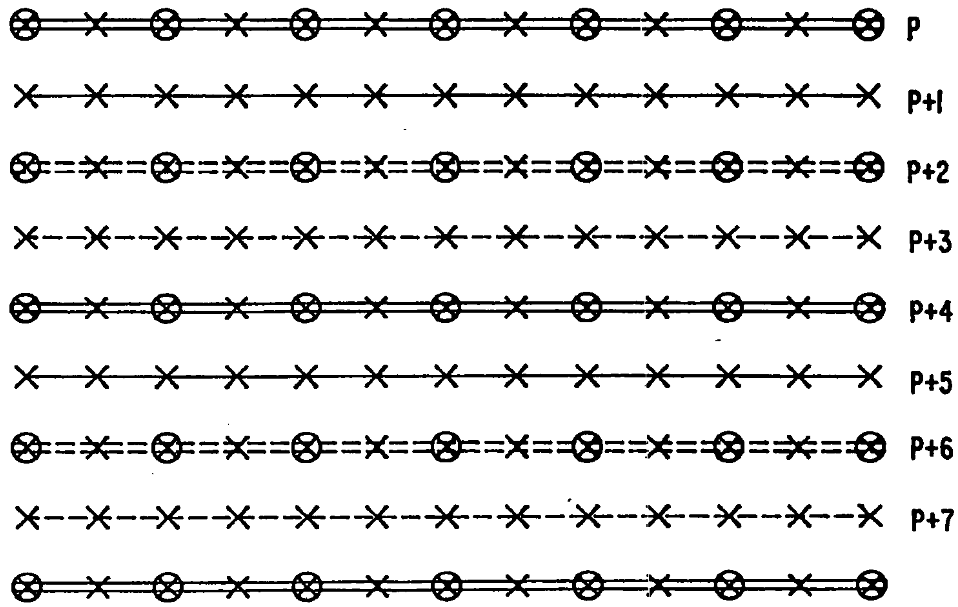

P
P+1
P+2
P+3
P+4
P+5
P+6
P+7

FIG. 6a.

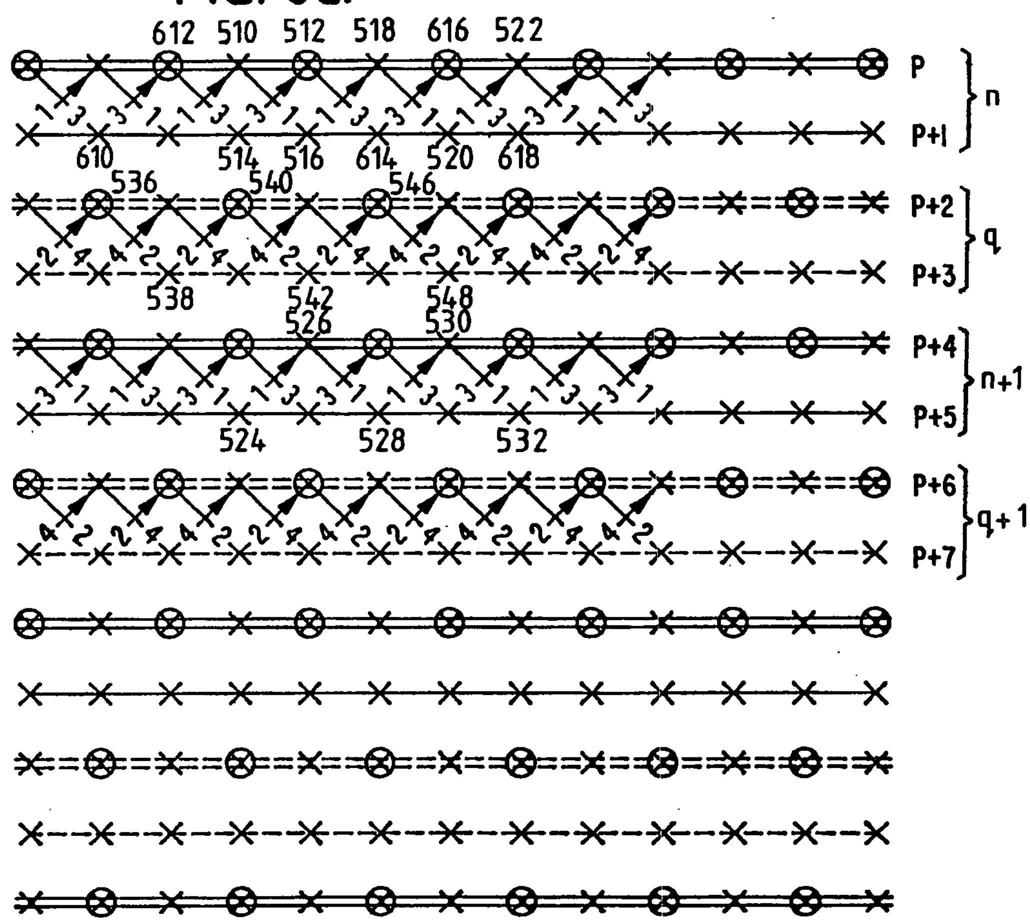

612 510 512 518 616 522
P
P+1
n
610
514 516 614 520 618
536 540 546
P+2
P+3
q
538
542 548
526 530
P+4
P+5
n+1
524 528 532
P+6
P+7
q+1

FIG.6b.

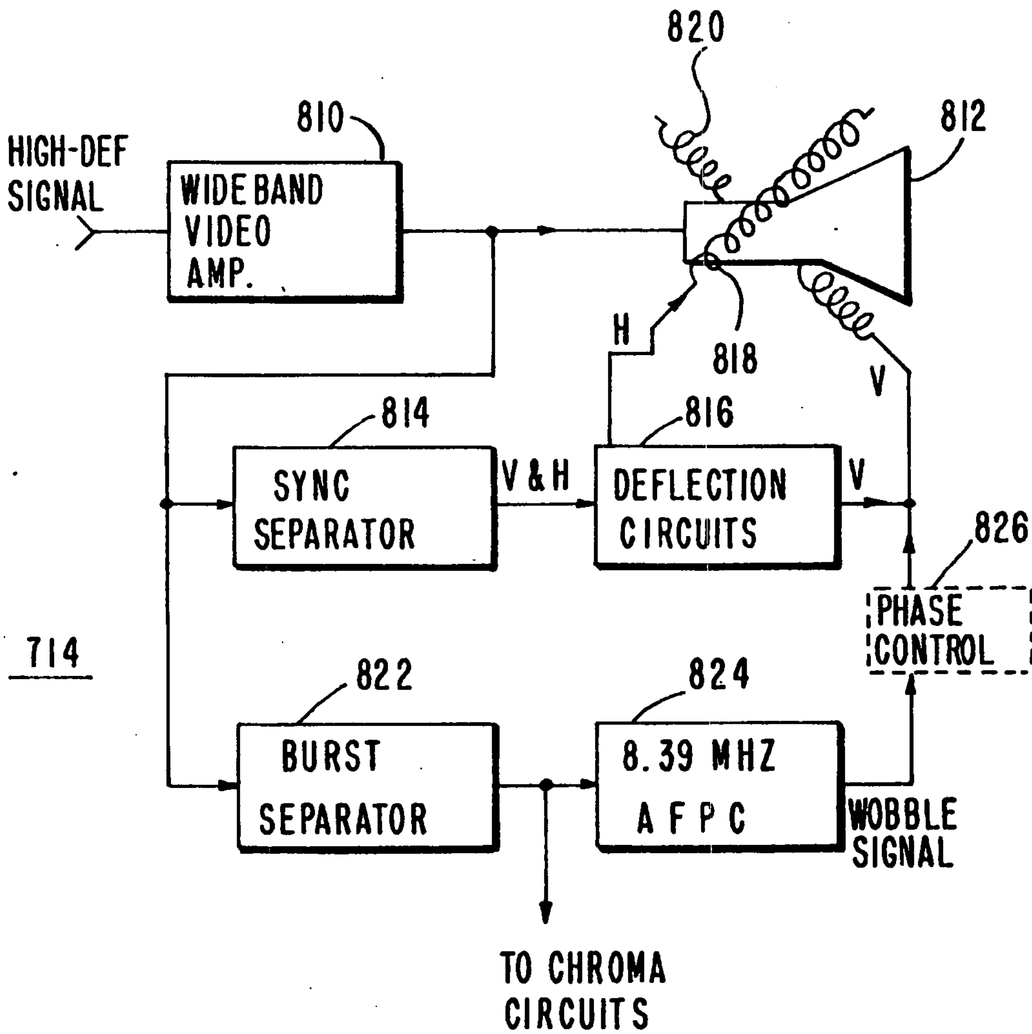

820
810
812
HIGH-DEF
SIGNAL
WIDE BAND
VIDEO
AMP.
H
818
V
814
816
SYNC
SEPARATOR
V & H
DEFLECTION
CIRCUITS
V
826
PHASE
CONTROL
714
822
824
BURST
SEPARATOR
8.39 MHZ
A F P C
WOBBLE
SIGNAL
TO CHROMA
CIRCUITS

FIG. 8.

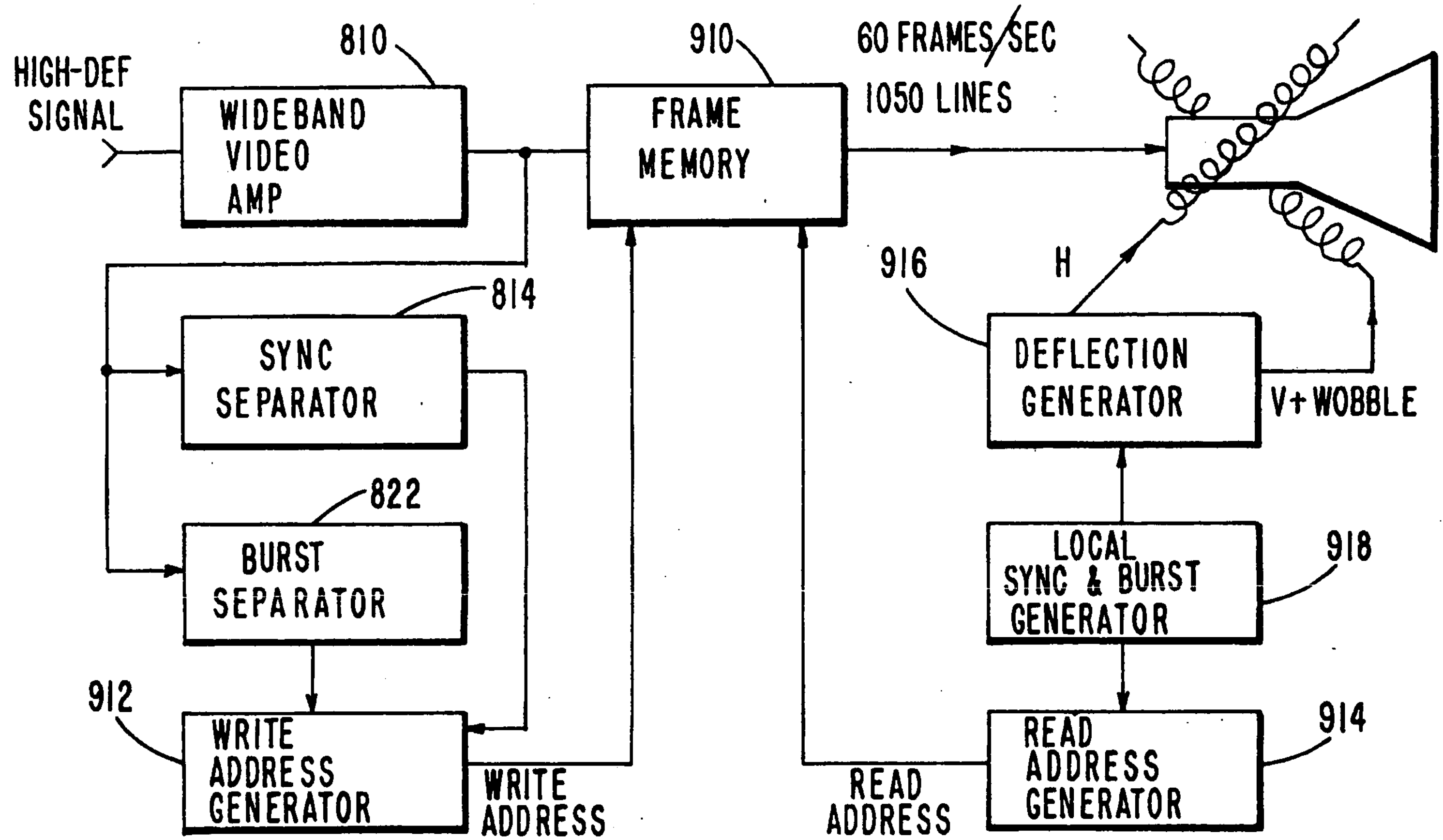

HIGH-DEF SIGNAL
810
WIDEBAND VIDEO AMP
910
FRAME MEMORY
60 FRAMES/SEC
1050 LINES
814
SYNC SEPARATOR
822
BURST SEPARATOR
912
WRITE ADDRESS GENERATOR
WRITE ADDRESS
READ ADDRESS
916
H
DEFLECTION GENERATOR
V+WOBBLE
LOCAL SYNC & BURST GENERATOR
918
READ ADDRESS GENERATOR
914

FIG. 9.

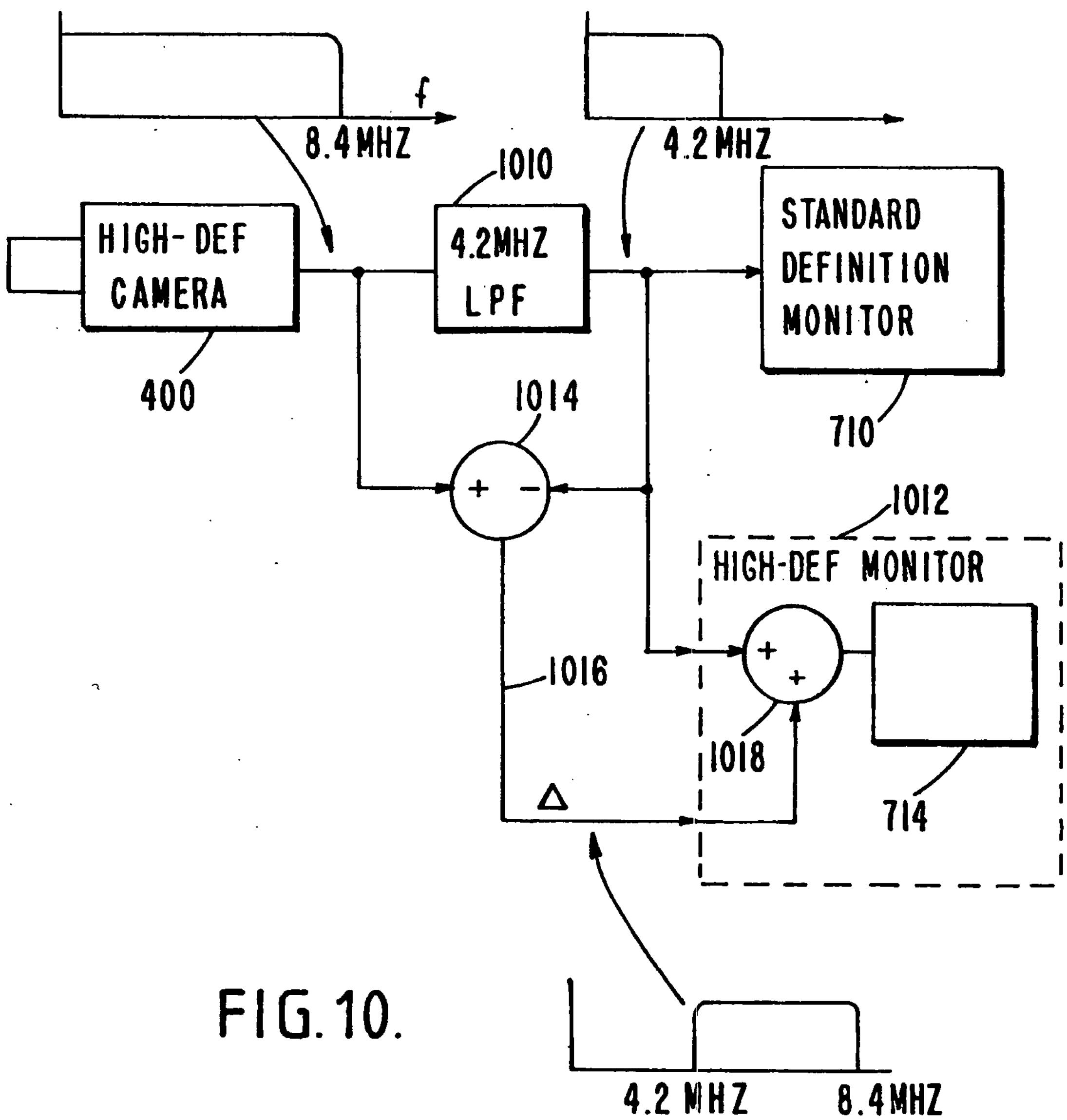

f
8.4MHZ
4.2MHZ
1010
4.2MHZ LPF
HIGH-DEF CAMERA
400
STANDARD DEFINITION MONITOR
710
1014
+
−
1012
HIGH-DEF MONITOR
+
+
1016
1018
714
Δ
4.2 MHZ
8.4MHZ

FIG.10.

FIG.11a.

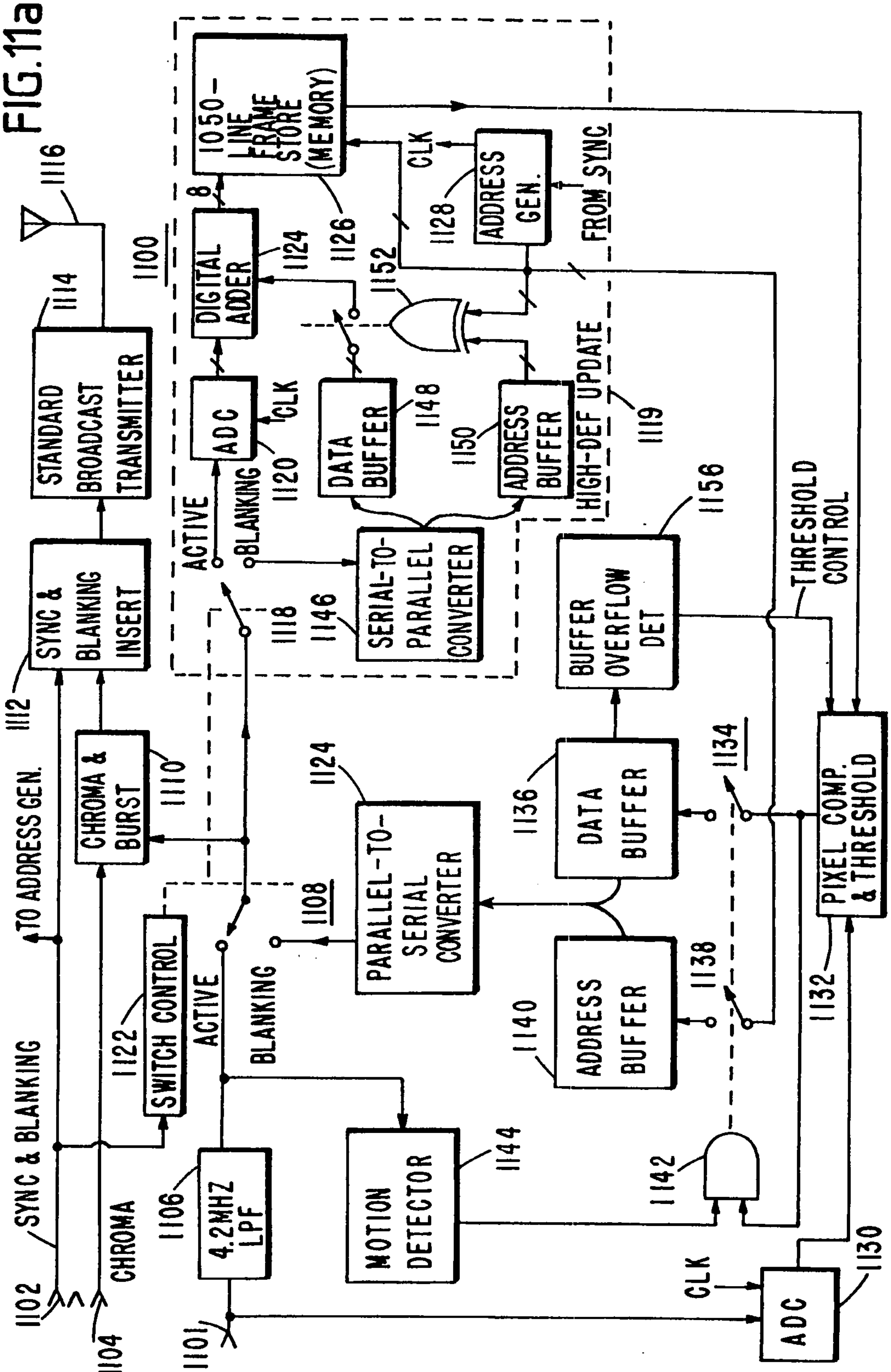

1116
1114
STANDARD BROADCAST TRANSMITTER
1100
1112
SYNC & BLANKING INSERT
1110
CHROMA & BURST
TO ADDRESS GEN.
SYNC & BLANKING
CHROMA
1102
1104
1101
1106
4.2MHZ LPF
1122
SWITCH CONTROL
ACTIVE
BLANKING
1108
1118
1120
ADC
CLK
8
DIGITAL ADDER
1124
1050-LINE FRAME STORE (MEMORY)
1126
CLK
1128
ADDRESS GEN.
FROM SYNC
1152
DATA BUFFER
1148
1150
ADDRESS BUFFER
HIGH-DEF UPDATE
1119
1146
SERIAL-TO-PARALLEL CONVERTER
1124
PARALLEL-TO-SERIAL CONVERTER
MOTION DETECTOR
1144
1136
DATA BUFFER
1140
ADDRESS BUFFER
1138
1134
1156
BUFFER OVERFLOW DET
THRESHOLD CONTROL
PIXEL COMP. & THRESHOLD
1132
1142
CLK
ADC
1130

FIG. 11b.

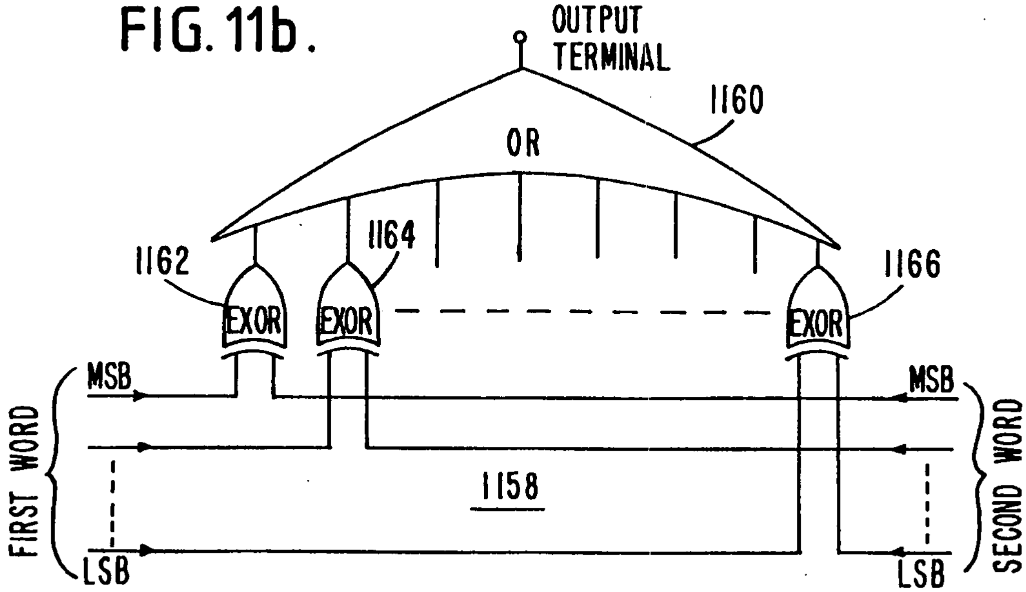
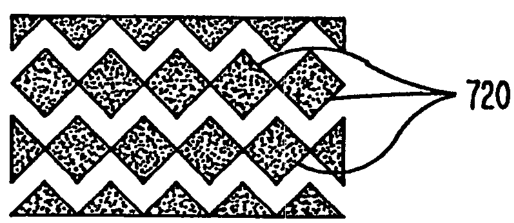
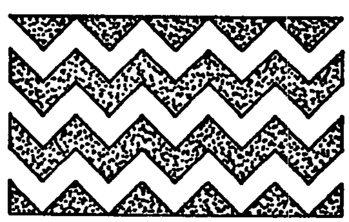


FIG. 13.

(a)



(b)



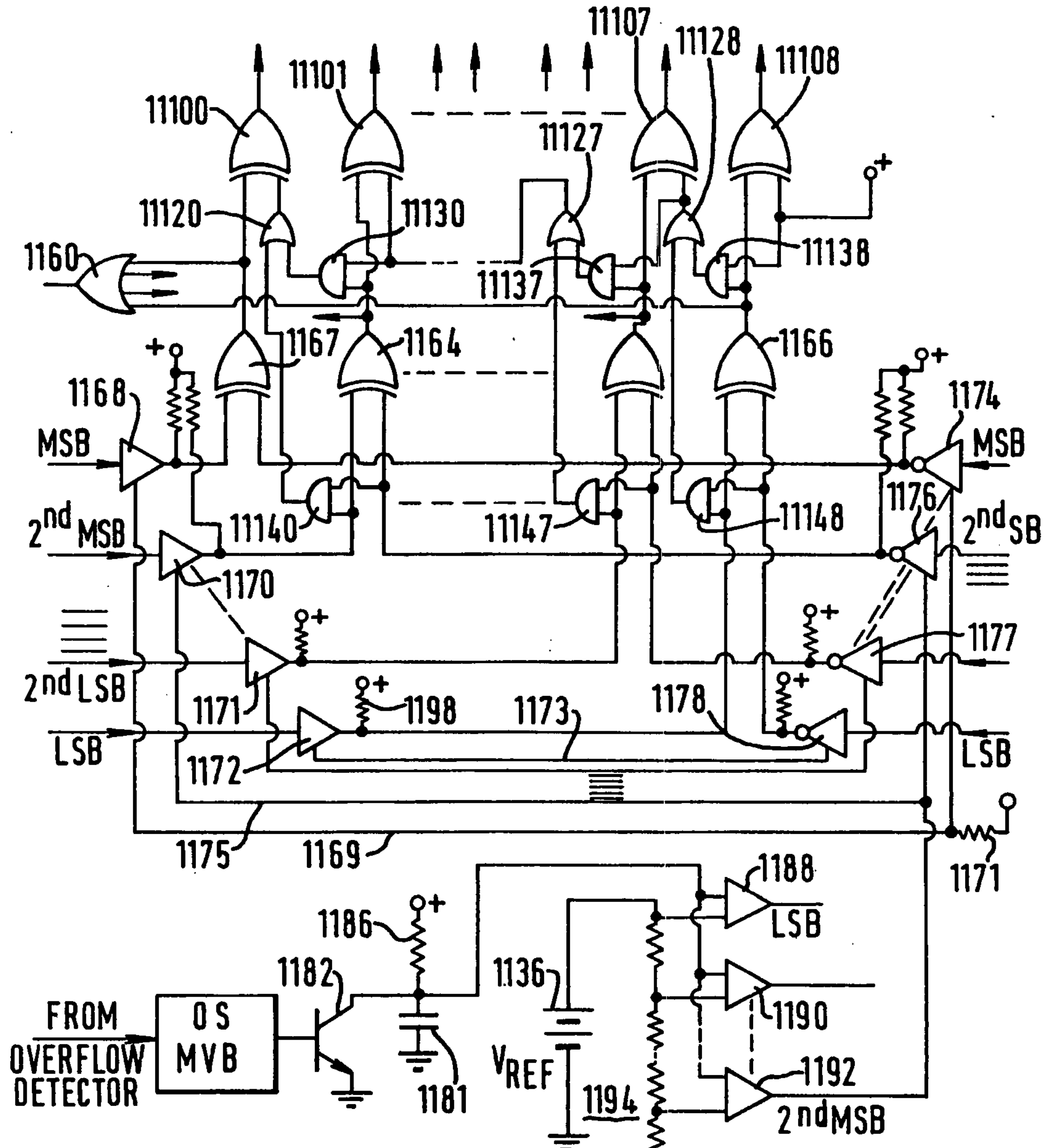

11100
11101
11107
11128
11108
11127
11120
11130
1160
11137
11138
1167
1164
1166
1168
MSB
2nd MSB
11140
11147
11148
1170
2nd LSB
LSB
1171
1198
1173
1178
1172
1174
MSB
1176
2nd SB
1177
LSB
1175
1169
1171
1188
LSB
1186
1182
1136
1190
FROM
OVERFLOW
DETECTOR
OS
MVB
VREF
1194
1192
2nd MSB
1181

FIG. 11C.

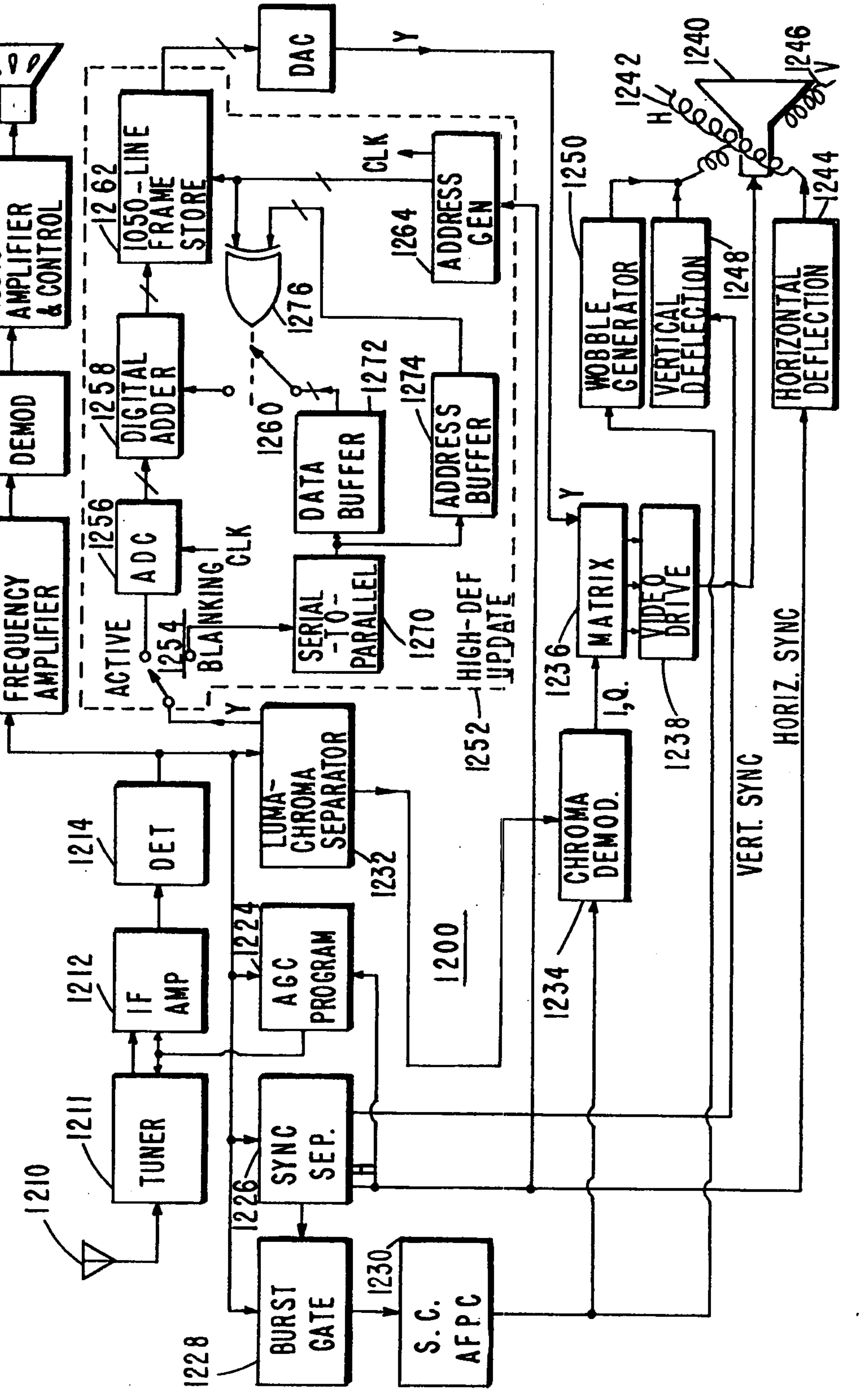

1210
TUNER
1211
IF AMP
1212
DET
1214
INTERCARRIER FREQUENCY AMPLIFIER
1216
AUDIO DEMOD
1218
AUDIO AMPLIFIER & CONTROL
1220
1222
AGC PROGRAM
1224
SYNC SEP.
1226
V
H
BURST GATE
1228
S.C. AFPC
1230
LUMA-CHROMA SEPARATOR
1232
Y
CHROMA DEMOD.
1234
I,Q.
MATRIX
1236
VIDEO DRIVE
1238
Y
1200
VERT. SYNC
HORIZ. SYNC
ACTIVE
1254
BLANKING
ADC
1256
CLK
DIGITAL ADDER
1258
1050-LINE FRAME STORE
1262
DAC
Y
1260
1276
DATA BUFFER
1272
ADDRESS BUFFER
1274
SERIAL -TO- PARALLEL
1270
ADDRESS GEN
1264
CLK
HIGH-DEF UPDATE
1252
WOBBLE GENERATOR
1250
VERTICAL DEFLECTION
1248
HORIZONTAL DEFLECTION
1244
1240
1242
H
1246
V

FIG. 12.

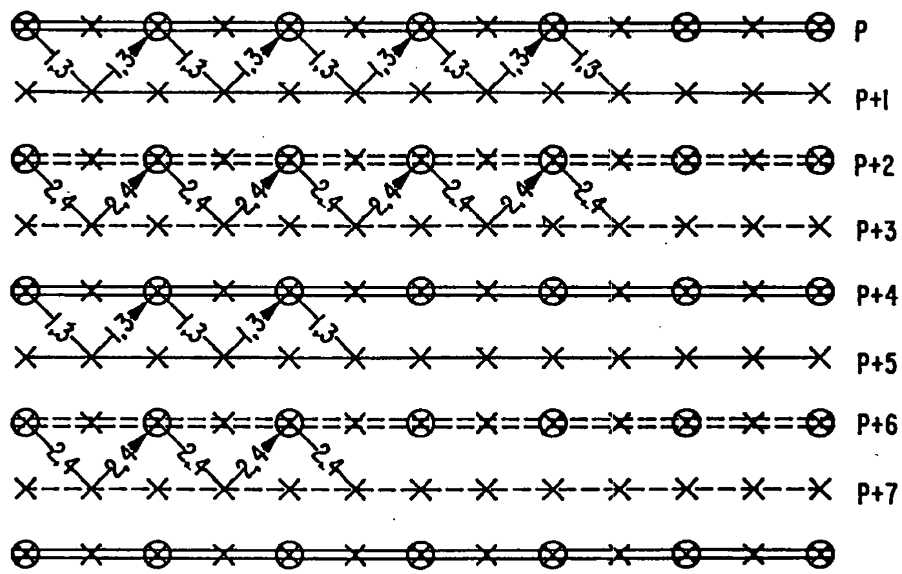


FIG. 14a.

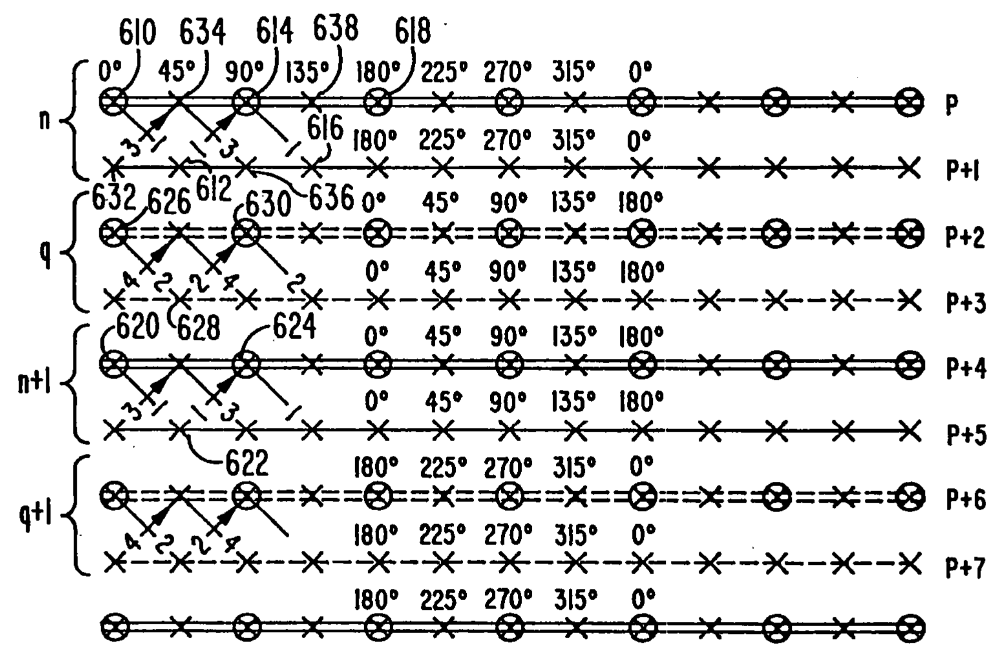
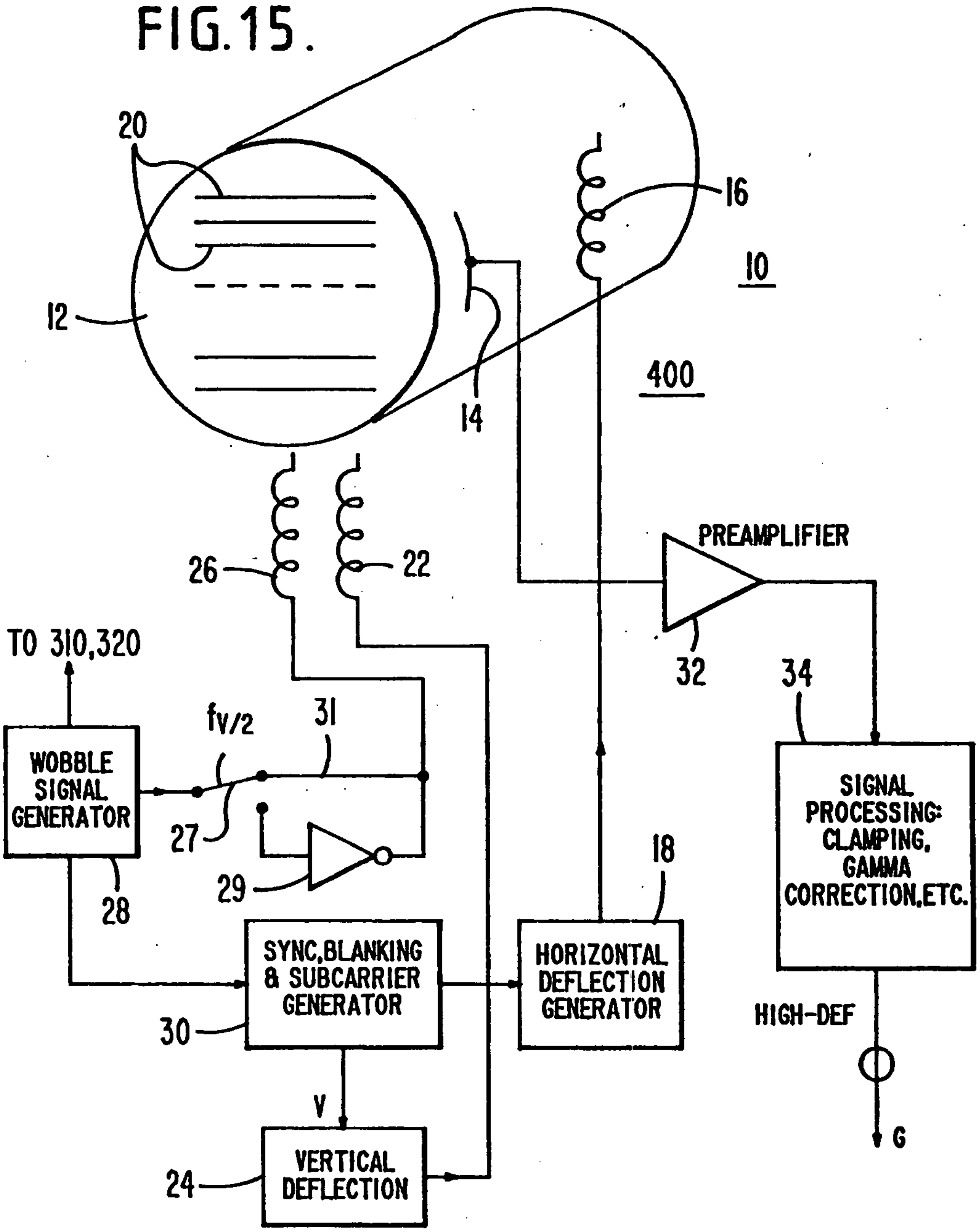


FIG. 14b. SUBCARRIER PHASE

FIG.15.


20
16
10
12
400
14
26
22
PREAMPLIFIER
TO 310,320
32
34
fv/2
31
WOBBLE
SIGNAL
GENERATOR
27
SIGNAL
PROCESSING:
CLAMPING,
GAMMA
CORRECTION,ETC.
29
18
28
SYNC,BLANKING
& SUBCARRIER
GENERATOR
HORIZONTAL
DEFLECTION
GENERATOR
30
HIGH-DEF
V
VERTICAL
DEFLECTION
24
G

2115641

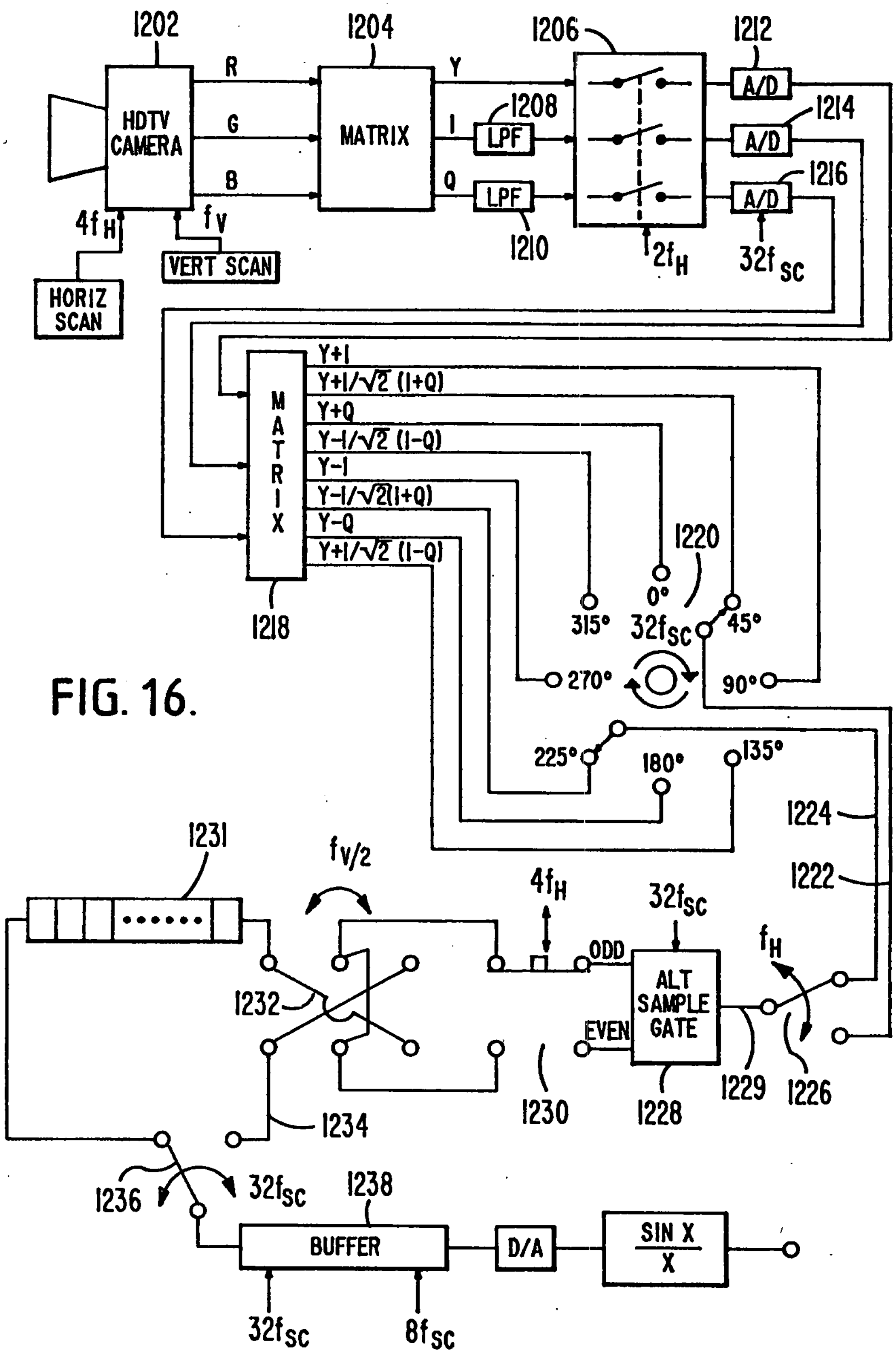


FIG. 16.

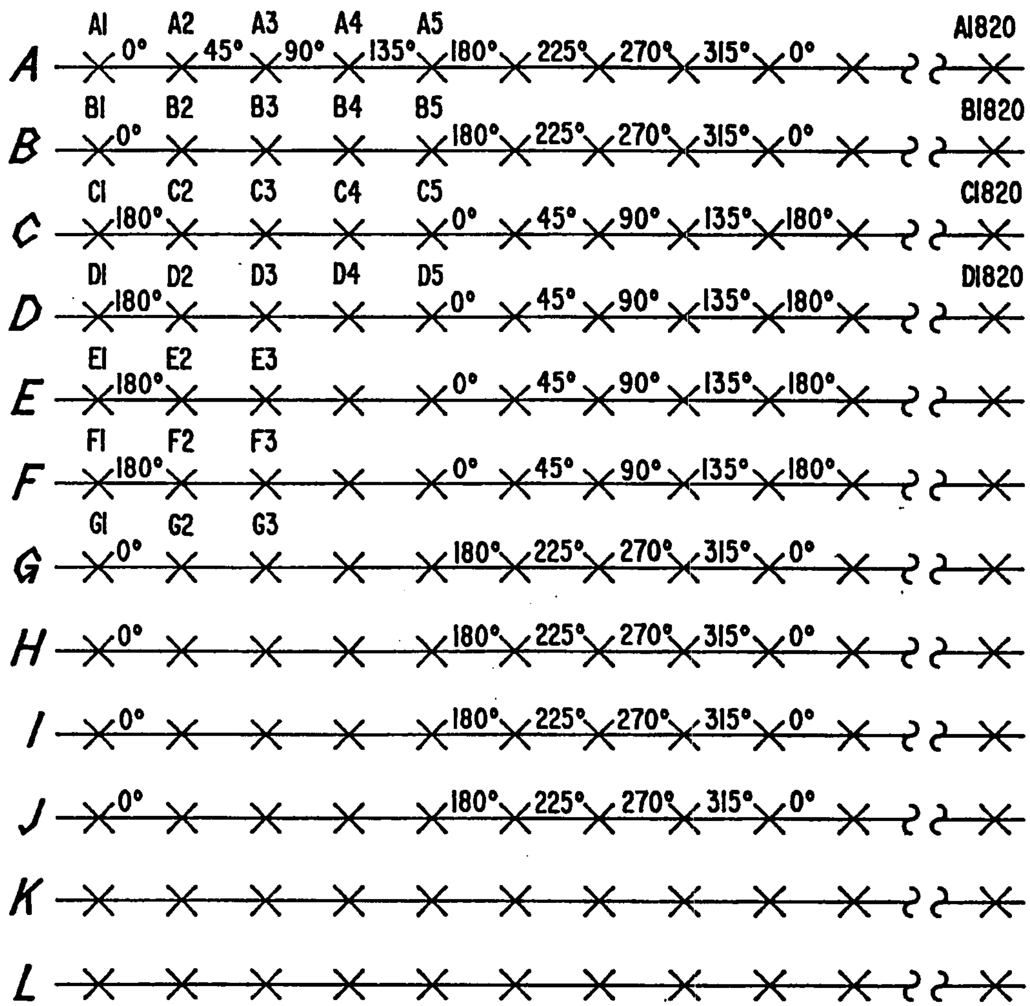

A1 A2 A3 A4 A5 A1820
A 0° 45° 90° 135° 180° 225° 270° 315° 0°
B1 B2 B3 B4 B5 B1820
B 0° 180° 225° 270° 315° 0°
C1 C2 C3 C4 C5 C1820
C 180° 0° 45° 90° 135° 180°
D1 D2 D3 D4 D5 D1820
D 180° 0° 45° 90° 135° 180°
E1 E2 E3
E 180° 0° 45° 90° 135° 180°
F1 F2 F3
F 180° 0° 45° 90° 135° 180°
G1 G2 G3
G 0° 180° 225° 270° 315° 0°
H 0° 180° 225° 270° 315° 0°
I 0° 180° 225° 270° 315° 0°
J 0° 180° 225° 270° 315° 0°
K
L

FIG.17a.

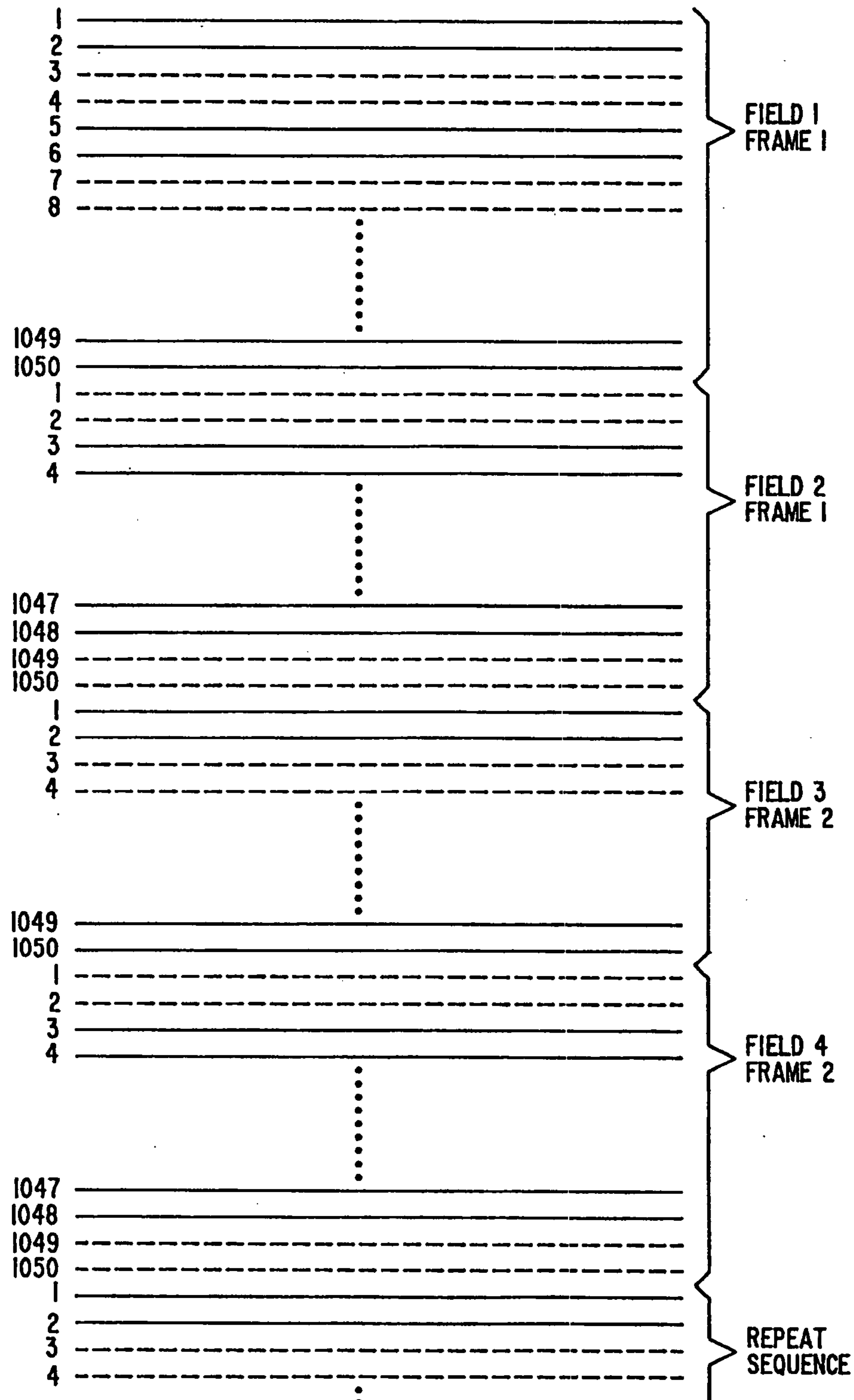

1
2
3
4
5
6
7
8
FIELD 1
FRAME 1
1049
1050
1
2
3
4
FIELD 2
FRAME 1
1047
1048
1049
1050
1
2
3
4
FIELD 3
FRAME 2
1049
1050
1
2
3
4
FIELD 4
FRAME 2
1047
1048
1049
1050
1
2
3
4
REPEAT
SEQUENCE

FIG.17b.

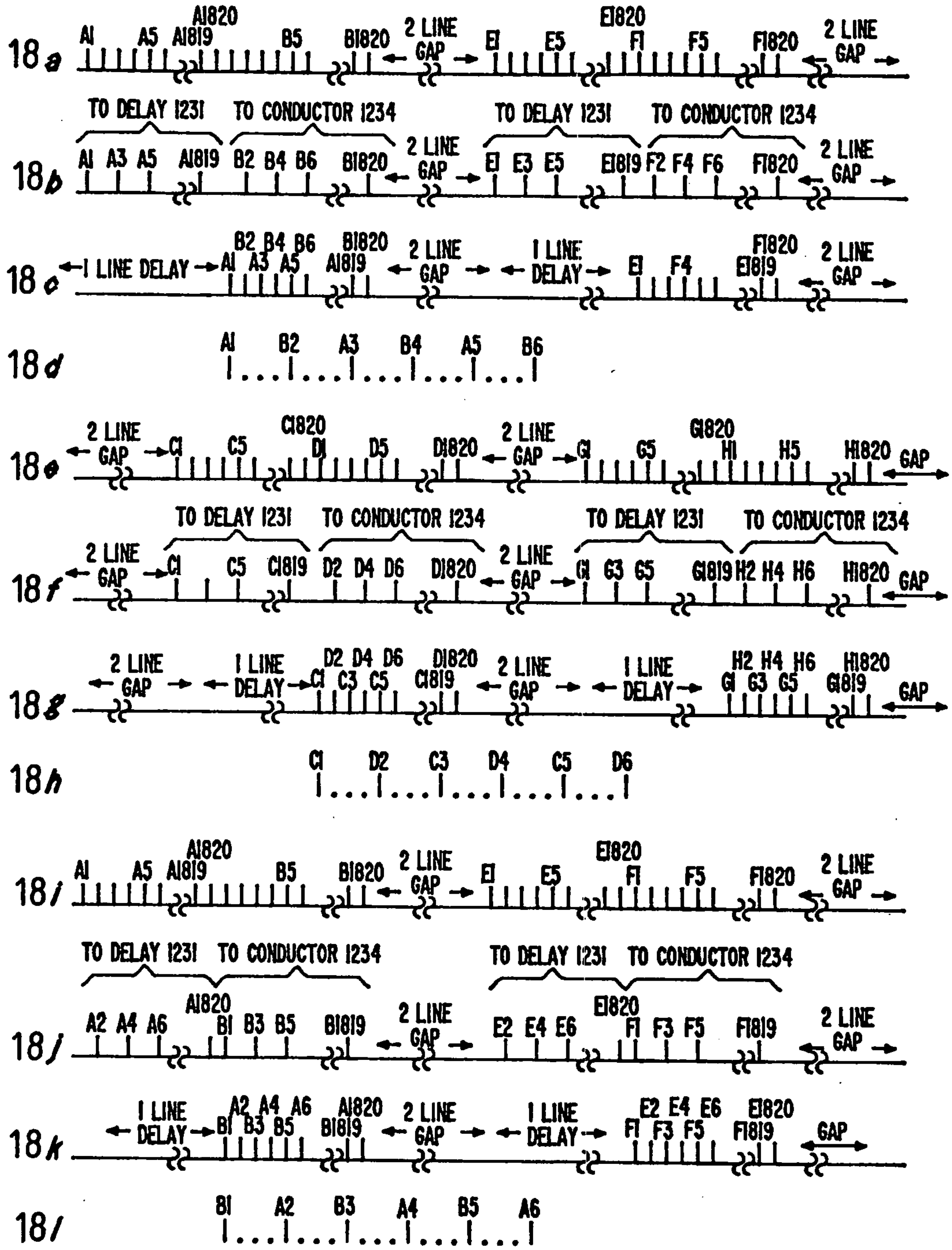

18a
A1 A5 A1819 A1820 B5 B1820 2 LINE GAP E1 E5 E1820 F1 F5 F1820 2 LINE GAP
18b
TO DELAY 1231 TO CONDUCTOR 1234 TO DELAY 1231 TO CONDUCTOR 1234
A1 A3 A5 A1819 B2 B4 B6 B1820 2 LINE GAP E1 E3 E5 E1819 F2 F4 F6 F1820 2 LINE GAP
18c
1 LINE DELAY A1 A3 A5 B2 B4 B6 A1819 B1820 2 LINE GAP 1 LINE DELAY E1 F4 E1819 F1820 2 LINE GAP
18d
A1 B2 A3 B4 A5 B6
18e
2 LINE GAP C1 C5 C1820 D1 D5 D1820 2 LINE GAP G1 G5 G1820 H1 H5 H1820 GAP
18f
TO DELAY 1231 TO CONDUCTOR 1234 TO DELAY 1231 TO CONDUCTOR 1234
2 LINE GAP C1 C5 C1819 D2 D4 D6 D1820 2 LINE GAP G1 G3 G5 G1819 H2 H4 H6 H1820 GAP
18g
2 LINE GAP 1 LINE DELAY C1 C3 C5 D2 D4 D6 C1819 D1820 2 LINE GAP 1 LINE DELAY G1 G3 G5 H2 H4 H6 G1819 H1820 GAP
18h
C1 D2 C3 D4 C5 D6
18i
A1 A5 A1819 A1820 B5 B1820 2 LINE GAP E1 E5 E1820 F1 F5 F1820 2 LINE GAP
18j
TO DELAY 1231 TO CONDUCTOR 1234 TO DELAY 1231 TO CONDUCTOR 1234
A2 A4 A6 A1820 B1 B3 B5 B1819 2 LINE GAP E2 E4 E6 E1820 F1 F3 F5 F1819 2 LINE GAP
18k
1 LINE DELAY B1 B3 B5 A2 A4 A6 B1819 A1820 2 LINE GAP 1 LINE DELAY F1 F3 F5 E2 E4 E6 F1819 E1820 GAP
18l
B1 A2 B3 A4 B5 A6

FIG. 18.

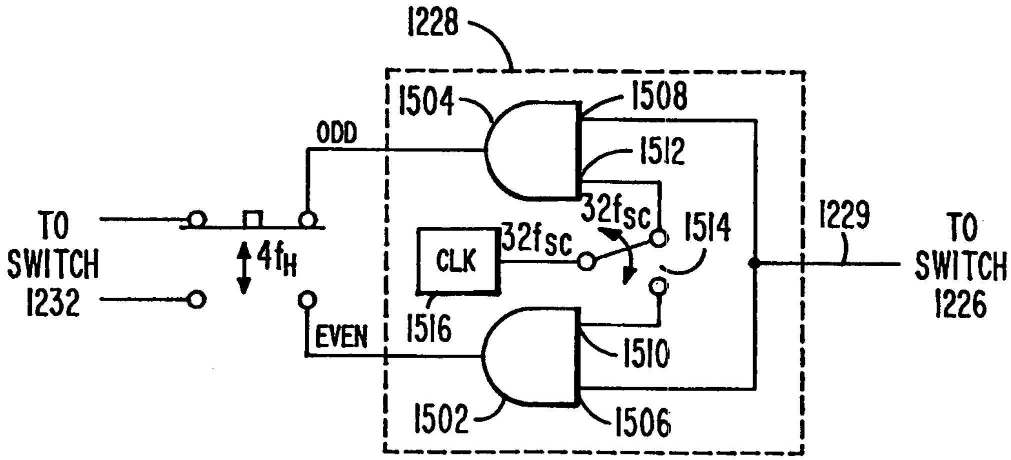

1228
1504
1508
1512
ODD
TO SWITCH 1232
4fH
32fsc
32fsc
1514
1229
TO SWITCH 1226
CLK
1516
EVEN
1510
1502
1506

FIG. 19.

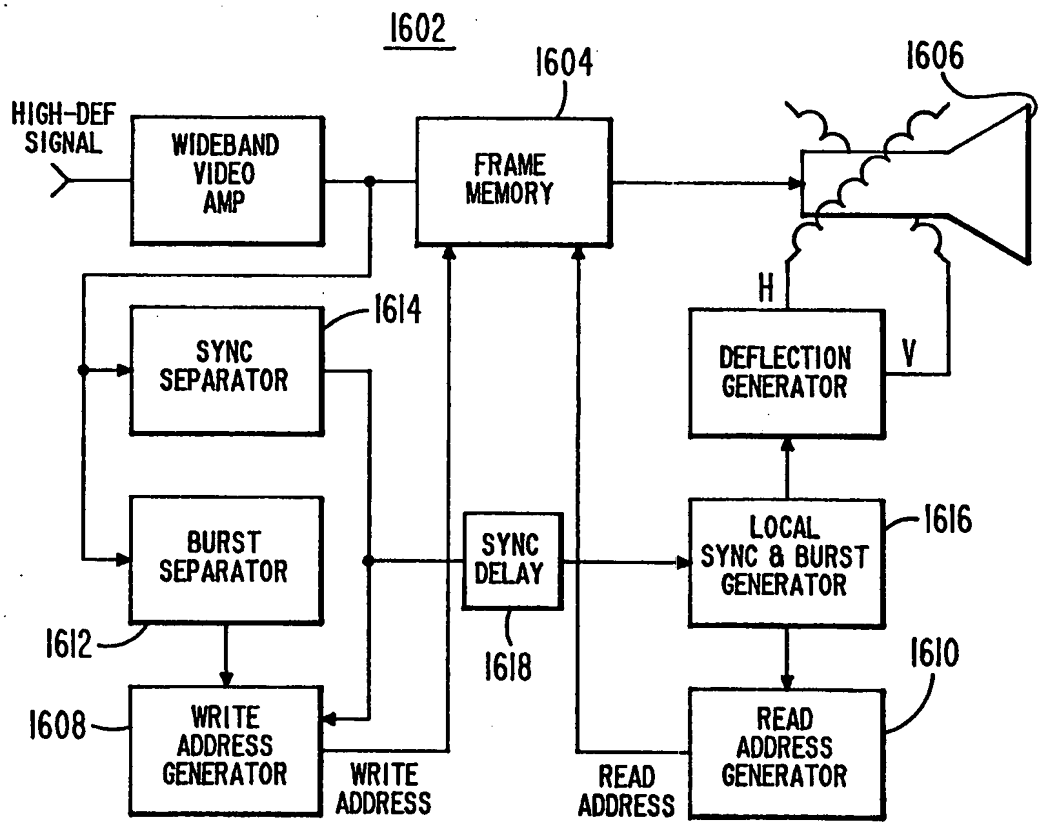

1602
1604
1606
HIGH-DEF SIGNAL
WIDEBAND VIDEO AMP
FRAME MEMORY
H
1614
SYNC SEPARATOR
DEFLECTION GENERATOR
V
BURST SEPARATOR
SYNC DELAY
LOCAL SYNC & BURST GENERATOR
1616
1612
1618
1610
1608
WRITE ADDRESS GENERATOR
WRITE ADDRESS
READ ADDRESS
READ ADDRESS GENERATOR

FIG. 20.

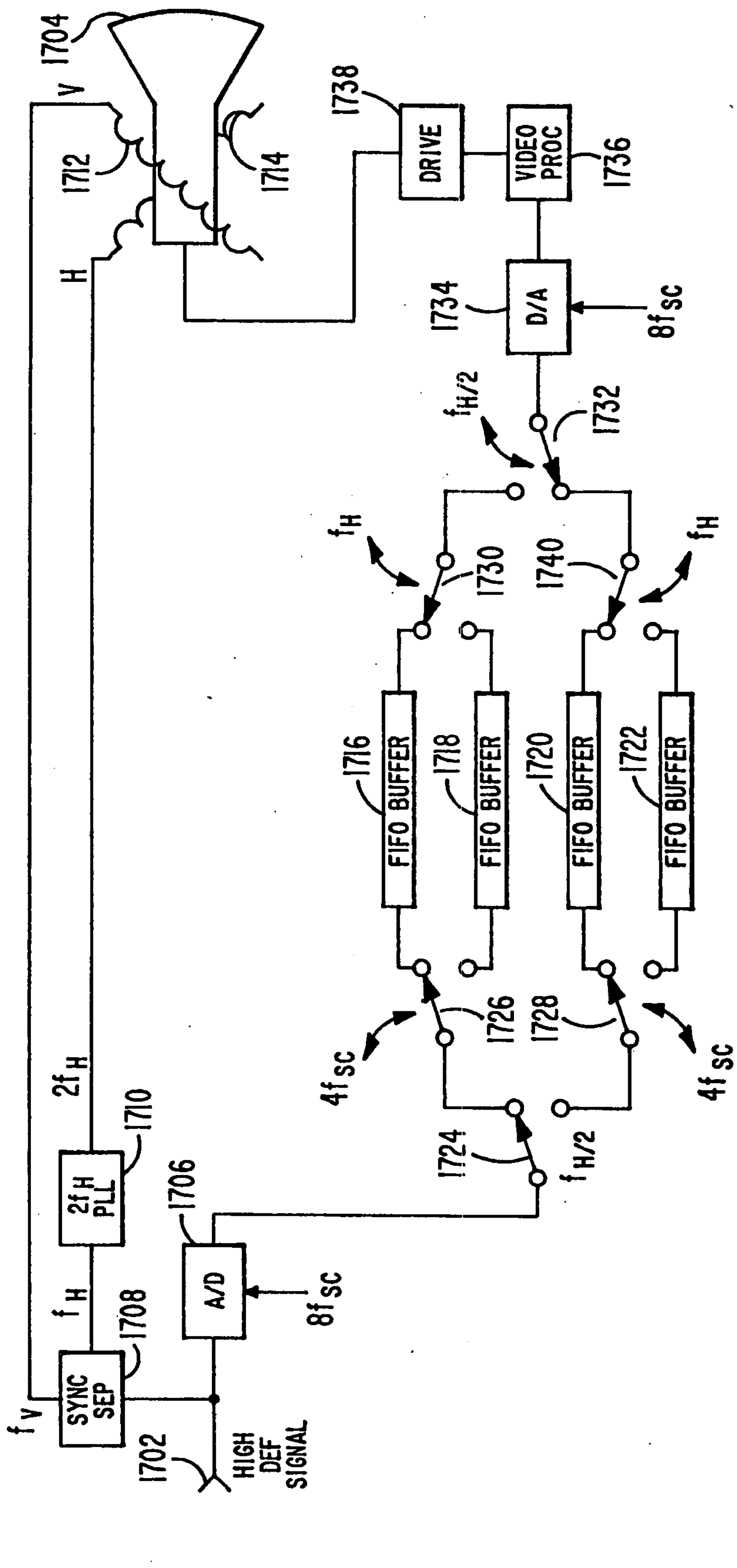

1704
V
H
1712
1714
1738
DRIVE
VIDEO PROC
1736
1734
D/A
$8f_{SC}$
$f_{H/2}$
1732
f_H
1730
1740
f_H
1716
FIFO BUFFER
1718
FIFO BUFFER
1720
FIFO BUFFER
1722
FIFO BUFFER
1726
1728
$4f_{SC}$
$4f_{SC}$
1724
$f_{H/2}$
$2f_H$
1710
$2f_H$ PLL
1706
A/D
$8f_{SC}$
f_H
1708
SYNC SEP
f_V
1702
HIGH DEF SIGNAL

FIG. 21.

SPECIFICATION

Television systems

The present invention relates to television systems. An illustrative application of the invention is to a television system having increased horizontal and vertical resolution as compared with, and which is compatible with, major standef (standard-definition) television standards. The invention is described, herein, in relation to that illustrative high definition television (HDTV) system.

Standard NTSC television scans 525 lines per frame in the form of two sequential fields of 262 1/2 lines each. The lines of each field interlace with the lines of adjacent fields and the eye integrates these interlaced lines to reduce the effect of 60 Hz field-rate flicker. However, the vertical line structure is still visible under certain circumstances, and is particularly visible on large-screen television displays viewed from a relatively close distance. The problem is made even more severe by the ultra-large pictures formed by projection-type television displays. The advantages of such ultra-large pictures in providing the illusion of surrounding the viewer are reduced by the need for the viewer to remain sufficiently far from the display to integrate the line structure.

An illustrative compatible high-definition television system is described in UK Application No. 8221308, Serial No. (2107151) which corresponds to U.S. Patent Application Serial No. 288,753 filed July 31, 1981 in the names of C. B. Oakley and R. A. Dischert. In this illustrative system, the visibility of the vertical line structure is reduced in a manner compatible with standef NTSC (or PAL) television by using a camera which generates two lines for every standard line (for example, 1050 lines-per-frame rather than 525), forming separate signals related to the sums and differences of pixels on adjacent raster lines, and transmitting as compatible signal the sum signal, together with the difference signal, which may be transmitted separately or concealed within a composite color signal. This arrangement increases the vertical resolution by increasing the number of vertical lines, which makes it possible to view an ultra-large picture from a closer distance without discerning the vertical line structure. With this system, the vertical luminance and chrominance resolution becomes about 1000 lines, while the horizontal resolution, which is established by the luminance bandwidth, remains at about 330 television lines. The horizontal resolution thus becomes the limiting factor in the distance between the viewer and an ultra-large display, once the vertical line structure becomes invisible.

High-resolution television systems have been proposed and constructed. These systems, however, use bandwidths of as much as 20 MHz in order to provide adequate horizontal resolution. It has heretofore been assumed that high horizontal resolution, on the order of 500 television lines, is incompatible with conventional NTSC or PAL systems, and that such improved resolution could only be transmitted to receivers by transmission channels having wide bandwidth (in excess of 6 MHz bandwidth for NTSC). Proposals for delivery of such service, therefore, have centered about DSB (direct satellite broadcast) or cable distribution systems.

It is very desirable to permit transmission of color television signals in a composite format compatible with a receiver of particular resolution so that the performance of such a receiver would not be seriously degraded, while at the same time, and within the same bandwidth limitations, include within the signal enough information to allow a special receiver to reconstruct a picture having relatively increased vertical and horizontal resolution.

Various aspects of the invention are set out in claims 1, 2, 14, 17, 18 and 20 to which attention is directed.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:—

Figures 1 and 2 illustrate vertical and horizontal lines on a raster, respectively;

Figure 3 illustrates the optical portions of a color camera;

Figure 4 illustrates camera vidicon and circuit arrangements;

Figures 5a, 5b, 6a and 6b illustrate in detail the scanning pattern of the camera of Figure 4 or of a high-resolution kinescope;

Figure 7 is a symbolic block diagram of a compatible television system;

Figures 8 and 9 are simplified block diagrams of television monitors;

Figure 10 is a simplified block diagram of a compatible high-definition television system;

Figures 11a to c are block diagrams of portions of a high-definition video encoder and broadcasting arrangement;

Figure 12 is a block diagram of a high-resolution receiver for compatible television signals encoded and broadcast by the encoder of Figures 11a to c;

Figures 13a and b are schematic diagrams showing scanning patterns produced according to techniques described herein;

Figures 14a and b are detailed diagrams showing scanning patterns;

Figure 15 is a diagram of a camera and circuit arrangements, modified as compared to the camera and circuit arrangements of Figure 4;

Figure 16 illustrates, partially in block diagram form, a high-definition video encoder;

Figures 17a and b illustrate in detail a high-definition raster which is linearly scanned;

Figure 18 is a timing diagram for use in explaining the operation of the encoder of Figure 16;

Figure 19 shows an embodiment of the alternate sample gate of Figure 16;

Figure 20 is a simplified block diagram of a progressively scanned television monitor; and

Figure 21 illustrates, in block diagram form a high definition television receiver using line stores.

In the following, the invention is illustrated with reference to the NTSC system.

Figure 1 illustrates a raster having an aspect ratio with a height of three units and a width of four units. The raster is scanned in the usual fashion by successive horizontal lines (not shown). Alternate light and dark vertical lines are displayed on the raster. The light and dark lines are related to the frequency of the signal being processed. The horizontal scanning time in NTSC is 63.5 microseconds of which approximately 10 microseconds is used for horizontal retrace and blanking, leaving approximately 53 microseconds as the duration of the active line scan. The alternate light and dark lines formed on the raster in Figure 1 require positive- and negative-going signal excursions, the rate of which is determined by the number and relative physical spacing of the lines of the object to be televised. If the luminance bandwidth of the television signal is effectively about 4 MHz as practiced in receivers, the highest-frequency signal which can pass through the channel can then go through a full cycle (one positive and one negative excursion of the luminance) in 1/4 μS. In 53 microseconds (the duration of the active portion of one horizontal line) approximately 220 complete cycles can take place. Thus, 220 black and 220 white lines can occur in one horizontal line, for a total of 440 television lines in a complete horizontal scan. However, in accordance with standard television practice, the horizontal resolution must be multiplied by 3/4 in order to determine the standard resolution (the resolution which would occur if the raster were square and had a width equal to the height). Thus, the horizontal resolution is about 330 television lines for a 4 MHz bandwidth, or approximately 80 television lines per megahertz. Using this criterion, the resolution in the horizontal direction for a color signal component having a 1.5 MHz bandwidth is about 120 television lines. The eye is much more sensitive to luminance variations than color variations, however, so that a picture having 120 lines of horizontal resolution in color and 330 lines in luminance will be perceived as having 330 line overall resolution.

In the vertical direction, each field consists of more than 250 scanned lines as suggested in Figure 2. The color resolution in the vertical direction is much better than in the horizontal direction, because the horizontal resolution is limited by the chroma channel bandwidth as mentioned above to about 120 television lines, whereas the vertical color resolution is not determined by the channel bandwidth but rather by the number of horizontal lines by which the picture is sampled in the vertical direction. Consequently, the color resolution in the vertical direction much exceeds the color resolution in the horizontal direction. The horizontal luminance resolution is inadequate, and as mentioned previously the vertical luminance resolution is not adequate since a line structure can be seen in large picture displays.

Figure 3 illustrates the optical portions of a high-resolution camera.

In Figure 3, light from a scene illustrated as an arrow 301 passes through an optical system illustrated as a block 302 and into a color-splitting prism 304. Green (G) light passes as is known through further optics 306 as required for focusing onto the photosensitive element or faceplate 12 of a vidicon 10. The red (R) components of the light from the scene are separated by prism 304 and are focussed by optics 319 onto the photosensitive element of vidicon 310. The blue (B) light is similarly separated by prism 304 and focussed by optics 314 onto the photosensitive element of vidicon 320. Vidicons 10, 310 and 320 are of the DIS (Diode-gun impregnated-cathode) saticon type or other type capable of resolution in excess of 1000 lines both horizontally and vertically. The vidicons are registered as required to superimpose the R, G and B rasters which they produce.

Figure 4 illustrates in simplified form a high-resolution vidicon 10 and its associated circuitry. Vidicon 10 includes a face plate 12 which includes on the back portion thereof a photosensitive target element coupled to a target electrode 14, an electron beam (not shown) deflected horizontally by magnetic fields associated with a horizontal deflection winding illustrated as 16 driven by a horizontal deflection generator 18 so as to scan the electron beam horizontally across faceplate 12 to produce horizontal scan lines illustrated as 20. The scanning electron beam is deflected in the vertical direction by a magnetic field associated with a vertical deflection winding 22 driven by a vertical deflection generator 24. An auxiliary deflection winding 26 is driven by a high-frequency signal from a wobble signal generator 28. The wobble signal produced by generator 28 is also applied as a timing signal to synchronizing signal, blanking signal, and subcarrier signal generators illustrated together as a block 30 by which horizontal deflection generator 18 and vertical deflection generator 24 are synchronized. The wobble signal produced by generator 28 is also applied to sync signal generators associated with vidicons 310 and 320 which correspond with sync generator 30. The scanning of the electron beam across faceplate 12 upon which the image is focused creates a signal at target electrode 14 in known fashion. The signal is representative of the image. The image-representative signal from target 14 is applied to a preamplifier 32 and to usual signal processing circuits such as black-level clamping, gamma correction and so forth, illustrated together as a block 34.

Figure 5a illustrates a television raster or image designated generally as 500 together with three scan lines n—1, n, and n+1 arbitrarily chosen from among the many scan lines making up the raster. Each scan line is made up of a large number of

picture elements, or pixels, the size of which is determined by the resolution capability of the television system. For a standef NTSC television system, the number of picture elements in each line is about 700. The first pixel of line n—1 is designated 501, and the last pixel is 502. In the NTSC television system, lines n—1, n and n+1 are laid down sequentially during one television field, and therefore are separated by sufficient distance to accommodate the interlaced lines of a second field forming a television frame. In Figure 5a, the region about an arbitrarily chosen pixel 504 of line n has been expanded as an aid to understanding. Those skilled in the art will understand that the square shape of the pixels is only illustrative. Figure 5b illustrates a portion of a raster pattern of a DIS high-resolution saticon expanded as in Figure 5a. Because of the high resolution of the saticon, the pixels are smaller, so that four pixels illustrated as 510—516 fit within the same space occupied by a single pixel in a standef scan. Pixels 510 and 512 may be considered to be portions of a subraster line p while pixels 514 and 516 may be considered to be pixels of a subraster line p+1. A DIS-type saticon can have its beam deflected in such manner as to produce a raster having 1050 horizontal lines, each line of which contained approximately 1400 pixels. When compared with the standef NTSC system, the number of scanning lines and the number of pixels per line are each doubled, which quadruples the spatial resolution. If high-resolution signals derived from a high-resolution camera scanned as in Figure 5b were to be transmitted to represent a picture utilizing the full resolution capability, and if that picture were to be transmitted at the rate of thirty frames per second as in standard NTSC, the required bandwidth would be four times the bandwidth required in the NTSC system, or

$$4.2\ \text{MHz} \times 4 = 16.8\ \text{MHz}.$$

Clearly, it is not possible to transmit a 16.8 MHz luminance signal through a standard 6 MHz NTSC channel having about 4.2 MHz allocated to luminance.

Figure 6a illustrates the image sampling raster of a high-definition television system configured for compatibility with a standard definition receiver. Sub-raster scan lines p, p+2, p+4, p+6, . . . correspond to the standard definition raster with solid lines corresponding to odd fields and dashed lines corresponding to even fields. The pixels denoted by the circles ⊗ form an orthogonal pattern for samples of a standef system occurring at an integral number of samples per line (at a sample frequency equal to an even integer multiple of one-half of the horizontal line-scan rate). The pixels denoted by "x" form the high definition television samples that occur on a high-definition raster having twice the horizontal and vertical resolution.

When wobble signal generator 28 energizes auxiliary vertical deflection winding 26 at a frequency which is an odd multiple of half the line scanning frequency and the amplitude of the wobble is controlled, each successive scan of a line n in a 525-line system explores across sub-raster lines *p, p+1* in a sinuous pattern illustrated in Figure 6b. Each successive scan of the line n explores one of two different sets of sub-pixels, which are the pixels of a 1050-line high-definition system as illustrated in Figure 6b.

In Figure 6b a high-definition television raster is scanned with a scanning spot which is wobbled at an odd integer multiple of one-half the horizontal line rate, i.e., $(2n-1)\ f_H/2$. The wobble scan is illustrated by the diagonal zig-zag lines 1, 2, 3, 4 to denote, respectively, the four-field sequence required to scan the complete high-definition television raster. The phase reversal of the wobble pattern on time-successive scan lines (p, p+4, p+2, p+6) is indicated. The wobble frequency is for example $1067 \times \frac{1}{2} f_h = 8.394229$ MHz in which f_h is the line-scan frequency and the integer 1067 is selected to provide a resulting frequency of just under twice 4.2 MHz, corresponding to double the resolution of standef NTSC. Thus in the first field (1) of the first frame during the nth line of the 525-line raster of saticon 10, the wobble denoted by zig-zag line 1 (having an arbitrary starting point) causes exploration of the sub-pixels including, in order, sub-pixels 510, 516, 518, 520, 522 . . . After scanning the nth line, sub-pixels 524—534 of the (n+1)th line are explored in a sinuous path. It will be noted that the sinuous path described by the raster wobbling at an odd multiple of half the lines scanning frequency causes an out-of-phase condition on scan lines laid down in time sequence, as for example, the pattern of sub-pixels 510, 516, 518 of the (n)th line is physically reversed relative to the pattern of sub-pixels 528, 530, 532 immediately below on the (n+1)th line. At the end of the monochrome field, a second interlaced monochrome field (2) is scanned, and in due course sub-pixels 536—548 of line q interlaced between lines n and n+1 are explored. During the first field (3) of the second frame, sub-pixels 610, 612, 514, 512, 614, 616, 618, of line n are explored and then sub-pixels (not numbered) of line n+1. During the second field (4) of the second frame sub-pixels along line 4 are scanned. It will be noted that the set of sub-pixels being explored during the second frame constitute a completely different set of sub-pixels to the set explored in the first frame.

Because of the interlacing of scanning of the sub-pixels of the lines e.g. p and p+1 of line n and p+2, p+3 of line q takes place on successive vertical scans, it follows that the 525-line scanning pattern of the camera must pass through two complete frames before every sub-pixel is explored. In this respect, the wobbling signal has the same time-phase characteristic as the color sub-carrier, which is also at a frequency which is an odd multiple of half the line scanning frequency, in that completion of a cycle of repetition requires a time duration of four fields.

Consequently, the output signal of the camera is a representation of a high-definition picture, but the high-definition picture is generated at a 15-Hz rate corresponding to two frames, rather than a 30-Hz rate for one frame. Since the high-definition picture is effectively generated at half the rate of the standard picture, the bandwidth required to transmit the picture is only 8.4 MHz, rather than 16.8 MHz for the 30-Hz high-definition picture. The interlaced sub-pixels recur at a 15-hertz rate, and consequently the 2:1 reduction in bandwidth is achieved at the expense of a 15-hertz inter-subpixel flicker. Such small-area flicker is not considered to be objectionable. Additionally, the inter-subpixel flicker can be reduced or eliminated by the use of a frame store, as described below.

As so far described, the high-definition camera of Figure 4, which scans a 525-line raster consisting of two interlaced fields of 262½ lines at a 30-hertz rate is completely display compatible with existing standard-definition 525-line monitors. This compatibility results from the bandwidth limitation of a standard-definition monitor to 4.2 MHz. With limited bandwidth, the monitor cannot resolve the sub-pixels generated by the sinuous sub-raster nor can it resolve the sinuous excursions, and so averages them. Since the scan rate is basically standard 525-line scanning, the receiver or monitor will display a standard picture, in spite of the fact that high-definition information is imbedded in the signal. A 15-hertz pixel flicker on the standef 525-line display device may occur which results from the fact that the sub-pixels of successive scans may be different, and may be averaged differently on successive frames as displayed. This small-area flicker is tolerable, especially since it is usually of small amplitude and also because the differences between adjacent sub-pixels which occasions the flicker occurs only in regions involving high-frequency transitions or fine detail of the picture. Figure 7 symbolically represents the fact that a signal produced by high-definition camera 400 of Figure 4 can be the source of signal for a standard-definition monitor 710 which is limited to a bandwidth of 4.2 MHz by a symbolic low-pass filter (LPF) 712 to produce a standard-definition picture, while a high-definition monitor 714 not so limited in bandwidth and properly arranged to decode the signal can produce a high-definition picture. Figure 8 illustrates in simplified block-diagram form the general structure of high-definition monitor 714. In Figure 8, the high-definition signal is amplified by a wideband video amplifier 810 for application to the electrodes of a kinescope 812. A synchronizing signal separator 814 is coupled to the output terminal of amplifier 810 and separates vertical and horizontal sync signals from the composite signal for application to vertical and horizontal deflection circuits illustrated together as a block 816. Horizontal deflection signals are applied from deflection circuit 816 to a horizontal deflection winding 818 associated with kinescope 812. Vertical deflection signals are similarly applied to a vertical deflection winding 820. A burst separator 822 is coupled to the output terminal of video amplifier 810 for generating a sub-carrier signal related to the burst, and applies the sub-carrier to chroma circuits (not shown) and to a wobble signal generator 824 which generates a wobble signal at approximately 8.39 MHz. The wobble signal so generated is combined with the vertical deflection signal for application to vertical deflection winding 820, so as to generate on display kinescope 812 a raster of 525 sinuous lines-per-frame at a 30-hertz rate. Amplifier 810 has sufficient bandwidth to prevent averaging of the sub-pixels and therefore the sub-pixels are reproduced at appropriate points on the sub-lines on the scanned raster to produce a high-definition image. A phase-control circuit illustrated as a block 826 may be coupled to control the phase of the wobble signal, to provide an effect similar to fine focus.

Figure 9 illustrates in simplified block-diagram form a high-definition monitor similar to that of Figure 8 but including a 1050-line frame memory 910 and associated WRITE address generator 912 and read address generator 914. This arrangement eliminates sub-pixel flicker by storing a high-definition frame of 1050 lines, corresponding to the high-definition information in four NTSC fields. The information is stored at the rate of the incoming signal by controlling WRITE address generator 912 with the aid of a signal derived from burst separator 822. On the read side, a local sync generator 918 determines the reading rate. This reading rate can be independent of the incoming signal rate and can provide the advantage of a progressive or non-interlaced scan. The advantages of a progressive scan in reducing the visibility of scan lines are described in detail in International Patent Application No. PCT/US82/01176 filed 31st August 1982.

As mentioned, the high-definition signals of the arrangements of Figures 4—9 produce a high-definition signal with an effective frequency range extending up to 8 MHz. In spite of the effective reduction from the 16 MHz, (which would have been required if the high-definition signal were generated at the 30-hertz rate rather than at the 15-hertz rate), it is clear that such a signal is not compatible with a standard NTSC broadcast signal because the 8 MHz signal bandwidth exceeds the 4.2 MHz luminance bandwidth available for the standef system.

Figure 10 illustrates an arrangement by which a standard-definition monitor can receive a luminance signal having a standard 4.2 MHz bandwidth while a high-definition monitor receives signals representative of high-definition information. In Figure 10, high-definition camera 400 produces a baseband signal having an effective frequency bandwidth extending to 8.4 MHz. The signal is applied through a 4.2 MHz low-pass filter 1010 to a standard-definition monitor 710. Thus, the high-frequency or high-

definition portion of the information generated by camera 400 is removed by filter 1010 before application to standef monitor 710. The limited-bandwidth signal is also applied to a first input terminal of a high-definition monitor 1012. A differencing circuit 1014 subtracts the limited-bandwidth signal at the output of filter 1010 from the full-bandwidth signal at the input of the filter to produce a difference signal having a bandwidth extending from 4.2 MHz to 8.4 MHz. This signal represents the high-definition portions of the signal, and the arrangement of filter 1010 and differencing circuit 1014 thus acts as a high-pass filter. The difference signal is applied to a second input of high-definition monitor 1012. Within monitor 1012, a summing circuit 1018 receives the limited-bandwidth signal (LBS) and the difference Δ signal and adds them together to regenerate the high-definition signal which is applied to monitor 714 to produce the high-definition signal.

In the arrangement of Figure 10, the high-definition signal is broken into two elements, the first element being a limited bandwidth signal which can be applied through a conventional 4.2 MHz luminance channel to a standef monitor and to a high-definition monitor, while the delta signal representative of the high-definition vertical and horizontal portions of the signal is carried to the high-definition monitor along a second channel illustrated as conductor 1016.

In the development of NTSC color television, the psychophysical properties of the human eye were considered and a marked reduction in the bandwidth required to accomplish color television transmission was achieved by taking advantage of the inability of the eye to perceive fine detail in color. In an analogous manner, another psychophysical property of sight is used to reduce the bandwidth necessary for transmission of a high-definition signal. The analogous characteristic of the eye which permits bandwidth reduction for high-definition television is the inability of the eye to resolve details in moving objects.

In principle, therefore, a television system does not require wide bandwidth whenever the scene is in motion.

The arrangements of Figures 4—10 describe a means for generating a high-definition picture in which the high-definition components include portions attributable to both vertical and horizontal directions.

Figure 11a illustrates a signal processor and transmitter 1100 for receiving high-definition luminance signals, chrominance and synchronizing signals and for generating a compatible signal in which the high-definition components of still portions of the picture are concealed within the blanking interval. In Figure 11a high-definition luminance signals generated by a sinuous scan as described in conjunction with Figures 4—6 are applied to an input terminal 1101 at upper left of the Figure. Associated synchronizing signals are applied to an input terminal 1102 and modulated chrominance signals are applied to an input terminal 1104. The high-definition luminance signals are applied to a 4.2 MHz low-pass filter 1106 to produce at its output terminal a limited-bandwidth signal. A major advantage of this system is that a single low-pass filter affects the bandwidth in both the vertical and horizontal directions, due to the $\pm 45°$ direction of the sinuous scan. During the active interval of each horizontal line, the limited bandwidth signal is coupled through a switch 1108 to a chrominance and burst inserting circuit illustrated as a block 1110 where the chrominance signal is added in a frequency-interleaved fashion with the luminance. The composite chrominance-luminance signal is applied to a further block 1112 in which sync and blanking signals are added to form a standard composite NTSC signal which is applied to a standard broadcast transmitter 1114 for application to a broadcast antenna 1116 for transmission to both standard receivers and to special receivers adapted to process high-definition signals.

During the active portion of each horizontal line, the limited-bandwidth signals are coupled by a switch 1118 to an analog-to-digital converter (ADC) 1120. Switch 1118 is ganged with switch 1108, and both are controlled by a switch control circuit 1122 so as to be in their upper positions during the active portion of each line and in the downward position during non-sync portions of the blanking portion of each horizontal line and during the non-sync portions of the vertical blanking interval. The digital signals at the output terminal of ADC 1120 are coupled to a digital adder circuit 1124 in which the value of the digitized limited-bandwidth signal may be modified by additions thereto of a signal applied at a second input to the adder, and the signal so modified is applied to an input terminal of a 1050-line frame store 1126. Frame store 1126 is controlled by a clock and address generator 1128 which receives synchronizing signals from terminal 1102. An ADC 1130 at lower left of Figure 11a has an input coupled to input terminal 1101 for receiving high-definition incoming signals and generating digital signals representative thereof which are applied to a first input of a pixel comparator and threshold circuit 1132. A second input of comparator 1132 receives from store 1126 digital signals representative of corresponding pixels from the previous high-definition frame. Comparator 1132 makes a pixel-by-pixel comparison for each address of the high-definition frame and produces a digital output signal representative of the difference between each pixel value and the value of the corresponding pixel of the previous frame, so long as the difference exceeds a set threshold. The difference signal is applied through a switch 1134 to a data buffer 1136, while at the same time switch 1138 applies the corresponding address to address buffer 1140. Switches 1134 and 1138 are ganged and controlled by an AND

gate 1142 responsive to the presence of a difference pixel at the output of comparator 1132, in conjunction with a signal from a motion detector 1144 coupled to the limited-definition signal at the output of filter 1106. Motion detectors per se are known, and such a detector is described in U.S. Patent Application Serial No. 226,712 filed January 21, 1981 in the name of Hurst. As so far described, limited-definition signals of a previous frame stored in memory 1126 are compared pixel-by-pixel with high-definition signals of the current frame, and the differences therebetween, if any, are stored in a buffer, together with the corresponding addresses of the data. It will be noted that the arrangement as described itself constitutes a form of motion detector, in that motion of a portion of the image between frames will result in an output from comparator 1132. However, these are only stored in the event that a motion detector responsive to the low-definition signal indicates that no motion exists. Thus, motion in high-definition portions of the image which does not give rise to detected motion in low-definition portions would result in storage of information in data buffer 1136. In contrast, gross motions of portions of the image which are detectable by motion detector 1144 prevents storage of data in buffer 1136. In those broad flat portions of the picture containing little high-frequency detail, the pixels of the limited-bandwidth signal stored from the preceding field will have the same values as the pixels of the high-definition signal with which they are compared, and therefore there will be no output from comparator 1132. Thus, the data stored in buffer 1136 and the corresponding addresses stored in buffer 1140 occur only for those addresses in which there is a still picture as between two successive frames and where high-frequency detail exceeding the resolution capacity of the reduced-bandwidth signal exists. The storage of data in buffer 1136 and corresponding addresses in buffer 1140 occurs during the active portion of each horizontal line of each frame. During the blanking intervals, including the vertical blanking interval and the horizontal blanking intervals if desired, switches 1108 and 1118 are thrown to their alternate positions by switch control 1122, and buffers 1136 and 1140 couple data in a parallel format to a parallel-to-serial converter 1124 for conversion to a serial format. The serial high-definition information is coupled through to the transmitter 1114 and antenna 1116 and is also coupled to a serial-to-parallel converter 1146 of a high-definition update assembly 1119 which converter loads corresponding data buffers 1148 and 1150. Switch control 1122 then returns switches 1108 and 1118 to the position shown to allow limited-bandwidth information once again to be coupled to transmitter 1114 and antenna 1116, and also to be coupled in digitized form to the input of adder 1124. As the incoming limited-bandwidth signal steps pixel-by-pixel through the frame of incoming information, address generator 1128 steps through corresponding addresses of store 1126 to allow signals from adder 1124 to be stored. When the address produced by generator 1128 reaches the first address contained in buffer 1150, EXOR gate 1152 detects the correspondence and closes switch 1154, and also enables a gate (not shown) to allow clock pulses to activate data buffer 1148 and address buffer 1150 to provide at a second input of adder 1124 the signal representative of the difference between the pixels of the limited-definition signal and the high-definition pixels of the previous frame. Adder 1124 adds these together to produce a new pixel which is stored at the corresponding address of store 1126 as part of the current frame. At the same time, a new address appears at the output of buffer 1150; which is the address of the reduced-definition pixel the last value of which did not correspond with its corresponding high-definition pixel. When that second address is reached, EXOR 1152 again closes switch 1154 to correct the value of the reduced-definition signal being stored to make it correspond with the high-definition equivalent signal. This process is repeated for the entire frame. At the end of the frame, the pixels in store 1126 accurately represent in high-definition the still portions of the picture.

During the first few frames of a still scene containing a great deal of high-detail information, buffer 1136 may overflow. This overflow is detected by an overflow detector 1156 which produces a threshold control signal which is applied to comparator 1132 to raise the threshold level of the differences which are considered significant. This tends to reduce the amount of overflow of the buffer. Details of comparator 1132 and its threshold operations are described below in conjunction with Figures 11b and 11c.

In operation, starting from a blank field, the first frame of limited-bandwidth information loads memory 1126 with a picture corresponding to that for a 4.2 MHz bandwidth; in other words it loads it with a standef picture, notwithstanding that the high-definition signal applied at terminal 1101 contains large amounts of detail. During the second frame, buffers 1136 and 1140 will be loaded with difference information, which will be coupled into the high-definition update unit 1119 during the next following blanking interval. During the third frame following the scene change, the information stored in memory 1126 will begin to be updated with high-definition information, and the updating will continue, so long as the scene is still, until the stored signal represents the image with all of its detail. If a video monitor could be coupled to the output of frame store 1126, a standef image of the scene would appear for the first two frames, and thereafter the detail information would come into focus.

Figure 11b shows details of a simplified digital comparator 1158 as an aid to understanding comparator 1132. In the Figure, an 8-bit or 8-input OR gate 1160 receives the output of eight individual EXOR gates. Each EXOR gate 1162—

1166 has two input terminals. A first input terminal of EXOR 1162 is coupled to the most-significant bit (MSB) of one of the 8-bit digital words to be compared, and the second input terminal is coupled to the MSB of the second of the digital words to be compared. Each of the gates 1164—1166 has its input terminals coupled to a bit of a particular significance of the digital words to be compared, and gate 1166 is coupled to the least-significant bit (LSB). The output signal of each EXOR is high unless its two input bits match. So long as any bit of the input words do not match, at least one EXOR will have a HIGH output, and the output signal of OR 1160 will be HIGH. Only if all the pairs are the same will the output signal of OR 1160 go LOW. Naturally, the number of EXOR gates will be equal to the number of bits in the words being compared.

Figure 11c illustrates digital comparator 1132 in block-diagram form. As can be seen, its general form is similar to that of comparator 1158, but comparator 1132 includes tri-state drivers 1168—1172 (equal in number to the number of bits in the digital word being compared), each of which is coupled in the path of a bit of the first word to its EXOR gate, and a further set of inverting tri-state buffers 1174—1178 similarly arranged for the second word. At the output terminal of each tri-state driver is a pull-up resistor coupled to a positive voltage source. Each buffer can pass to its output terminal the HIGH or LOW at its input, or can be forced to a high-impedance condition at its output terminal by actuating a control bus to a LOW state. The control bus for drivers 1168 and 1174 is designated 1169, that for drivers 1170 and 1176 is designated 1175, and for LSB drivers 1172 and 1178 the control bus is 1173. In the high-impedance mode, the output of each driver is pulled HIGH by its associated pull-up resistor, causing the appearance of a binary ONE. When a control bus is pulled LOW, the pair of associated drivers goes high-impedance and their outputs are pulled HIGH to produce a pair of artificial ones, whereupon the EXOR coupled to the output of the driver pair declares its two input bits to be identical, whereby the EXOR output goes LOW, regardless of the actual state of the bits applied to the inputs of the drivers. Thus, if control bus 1173 for the LSB is pulled LOW, then EXOR 1166 will always find the LSB of the two words to be identical, and the actual values of the bits will be ignored in making the comparison. By controlling the number of bits forced to the artificial ONE condition, the number and significance of the bits being compared may be modified, by which a threshold may be established and moved about. In Figure 11c, bus 1169 coupled to the MSB drivers is pulled high by a resistor 1171, so the MSB of the digital words are always compared. The remainder of the control buses are controlled by a series of comparators 1188—1192. Each comparator has a first input coupled to a point on a resistive voltage divider 1194 coupled across a reference voltage source illustrated as a battery 1196. Comparators 1188—1192 have their second input terminals coupled in common across a capacitor 1184. A resistor 1186 is coupled to charge capacitor 1184, and a transistor switch 1182 is coupled across capacitor 1184 for discharging the capacitor. Transistor 1182 is controlled by a retriggerable one-shot multivibrator (OS) 1180 triggered by a signal from data buffer overflow detector 1156 of Figure 11a.

The remainder of the arrangement of Figure 11c including EXOR gates 11100—11108, OR gates 11120—11128, and AND gates arrays 11130—11138 and 11140—11148 are arranged to complete a subtractor circuit by which the digital words applied to tristate drivers 1174—1178 (the stored video signal) from the digital words applied to drivers 1168—1172 (the high-definition signal) to provide an N-bit parallel output signal from EXORS 11100—11108 representing the difference.

In operation, an overflow of buffer 1136 during a scene change produces an output signal from detector 1156 which triggers OS 1180, which responds with a timed drive to the base of a switch transistor 1182 of sufficient duration to discharge capacitor 1184. With capacitor 1184 discharged, comparators 1188—1192 respond by driving their respective control buses 1173—1175 to a LOW voltage condition, which forces all the tristate drivers except the MSB to their high-impedance states. By virtue of the pull-up resistors at the outputs of the drivers, all the driver outputs except the MSB assume an artificial ONE condition, and are ignored in making the comparison of the high-definition signal with the stored limited-definition signal. Consequently, only the largest high-definition transitions are stored in data buffer 1136. As capacitor 1184 charges, first comparator 1192 controlling the second MSB produces a LOW on bus 1175, allowing drivers 1170, 1176 to pass the second MSB of the words being compared, to store and ultimately transmit finer detail than the MSB alone. With increasing time, the remainder of comparators 1188—1190 in turn pull their respective buses low until the LSB is included in the comparison.

Figure 12 illustrates in simplified block-diagram form a television receiver adapted for receiving and displaying broadcast high-definition signals encoded according to the arrangement of Figure 11. In Figure 12, an antenna 1210 at upper left receives a plurality of broadcast signals which are applied to tuner 1211, which selects a single broadcast channel from among the signals, filters and down-converts the desired signal to an intermediate frequency (IF). The IF signal is applied to an IF amplifier 1212 where it is further amplified and filtered for application to a video detector 1214 in which the signal is demodulated to produce baseband video signal together with an intercarrier sound signal, as is known in the art. The intercarrier sound signal is selected by an intercarrier frequency amplifier 1216, filtered and

amplified and applied to an audio demodulator 1218 to generate baseband audio. The baseband audio is applied to amplifiers and controls illustrated as a block 1220 for application to a loudspeaker 1222. The detected luminance signal at the output of detector 1214 is also applied to an automatic gain control (AGC) programmer 1224 producing an AGC control signal which is applied to tuner 1211 and amplifier 1212 to maintain a relatively constant video level. The baseband video output signal from detector 1214 is also applied to a sync separator 1226 which separates the various synchronizing signals for use throughout the receiver. A burst gate 1228 is coupled to the output of detector 1214 and sync separator 1226 for gating a burst signal to a sub-carrier (SC) regenerator 1230 which may be in the form of an AFPC loop. The frequency-interleaved luminance and chrominance portions of the signal at the output of detector 1214 are separated by a luminance-chrominance separator 1232 which may include a comb filter. The chrominance portion is applied to chrominance demodulators 1234 which also receive sub-carrier signals from regenerator 1230 for demodulating color-difference signals such as I and Q from the separated chrominance. I and Q signals are applied to a matrix 1236 where they are combined with a reconstituted high-definition luminance (Y) signal to form R, G and B signals which are applied to a video drive stage 1238 for application to a kinescope 1240. A raster is scanned on kinescope 1240 by a horizontal deflection winding 1242 driven by a horizontal deflection circuit 1244. The vertical component of the raster is generated by a vertical deflection winding 1246 driven by a conventional vertical deflection circuit 1248. A wobble in the vertical deflection is introduced by a wobble signal superimposed upon the conventional vertical sawtooth by a wobble generator 1250 synchronized with the aid of the sub-carrier.

The separated luminance signal at the output of separator 1232 is applied to a high-definition update unit 1252 very similar to update unit 1119 of encoder 1100. Update unit 1252 includes a switch 1254 which is operated by a switch control (not shown) for switching the luminance signal between an active and a blanking position. In the active position the separated luminance signal is applied to an ADC 1256 where the signal is quantized, digitized and filtered, and it is applied to an input of a digital adder 1258 to be summed with a high-definition difference signal applied to a second input of adder 1258 through a switch 1260. The summed signal is stored in 1050-line frame store 1262. The address at which the incoming signal is stored is established by an address generator 1264 synchronized by signals from separator 1226. The stored luminance is periodically read out through a DAC 1268 to produce high-definition analog luminance signals for application to matrix 1236.

During the blanking intervals, switch 1254 couples the Y signal containing high-definition update information together with the addresses at which the update information is to be added to serial-to-parallel converter 1270 for conversion to parallel form and application to data buffer 1272 and address buffer 1274. During the next following active-video interval, switch 1254 is switched to its upper position, and limited-definition video is applied to digital adder 1258 while address generator 1264 produces addresses corresponding to the addresses of the video being stored in memory 1262. EXOR 1276 compares the address currently appearing at the output of address buffer 1274 with the current address of generator 1264 and closes switch 1260 when the addresses match. It also enables buffers 1272 and 1274 by paths (not shown) to clock one pixel of difference data and one address through buffers 1272 and 1274, respectively. Switch 1260 then opens until the next match of the address at the output of buffer 1274 with the current address of generator 1264. Gate 1276 continues throughout the entire frame to couple the high-definition update difference signals stored in data buffer 1272 to adder 1258 at the proper address. Thus, the signals stored in memory 1262 will track the signals stored in memory 1126 of encoder 1100. As mentioned, encoder 1100 stores in memory 1126 a standef signal for the first frame after a scene appears from a blank raster, and gradually improves the resolution of fine detail in stationary portions of the image. Consequently, receiver 1200 when receiving a high-definition signal will provide a standef image for the first frame following a blank raster, and will also gradually improve the resolution of high-definition portions of the scene. The subjective effect is that the stationary portions come into focus slowly but not so slowly as to be objectionable to the ordinary viewer. Areas of the raster containing motion do not carry high-definition detail.

Other embodiments of the invention will be apparent to those skilled in the art. For example, a single high-definition DIS-type saticon may be used to generate a high-definition luminance signal, with the lower-definition color signal being generated by three separate standef vidicons, or alternatively the color signal may be formed by matrixing together a signal derived from a green-responsive single DIS saticon and red- and blue-responsive standef vidicons. Wobble rates other than 8.39 MHz can be used, as for example three times the color sub-carrier frequency, or 10.738635 MHz. While the foregoing description of the embodiments is principally in terms of NTSC standards, the invention is applicable to other standards such as PAL and SECAM. The wobble deflection may be generated by a separate winding and generator or wobbling may be by superposition of a wobble-rate signal upon the nominal sawtooth signal applied to the vertical deflection winding. The scan wobble at the camera can be generated synthetically, as by scanning 1050 lines-per-frame without wobble,

writing into a frame store, and reading out with an address generator which selects pixels sequentially from adjacent lines.

It will further be obvious that analog equivalents of functions described in digital terms may be used. Specifically, charge-coupled devices may be used for frame stores rather than digital RAMS. Progressive or interlaced scanning may be used, and the rate at which the memory is interrogated may be different from the writing rate. Also, digital equivalents of functions described in analog embodiments may be used. Specifically, a counter counting sub-carrier cycles and triggered by the output of overflow detector 1156 may use a logic circuit responsive to a number of unique counts of the counter to control the tristate drivers of Figure 11.

While the above described embodiments increase only the luminance resolution, the same technique may be utilized to increase the definition of a color-difference signal. However, present practice under-utilizes the United States FCC-standard for standef television, in that present practice provides a bandwidth of color-difference signal I of only 500 KHz, while FCC standards allow 1.5 MHz bandwidth. Full utilization of the standef color standards to improve the color resolution will reduce the need to use the invention for proportional increase of color resolution.

In the illustrative compatible high-definition television system described hereinbefore, the scanning spot in the camera (Figure 4) is wobbled to double the resolution in both the horizontal and vertical directions of the high-definition display. The wider bandwidth signal which is transmitted is compatible with standef television receivers. The effect of the narrow bandwidth of such receivers is to average the values of adjacent pixels in both horizontal and vertical directions. In the high-definition wider bandwidth television receiver, the scanning spot is synchronized to wobble in accordance with the wobble that was introduced by the camera. The spot is wobbled at a rate equal to an odd integer multiple of one-half of the horizontal scan frequency so that a complete high-definition raster of pixels is traced out over four successive fields.

A disadvantage of spot wobbling at an odd integer multiple of one-half the horizontal line rate is that certain scanning artifacts on the television display may become visible and be objectionable to the viewer. When the spot is wobbled at an odd integer multiple of one-half the horizontal rate the wobble phase on successive lines of a given field differ by 180°. Therefore, the scanning line structure will display a visible high-frequency modulation of the space between adjacent lines of the same field giving the picture an appearance of an array of black dots superimposed over the image. The interstitial lines of one field will not overlay on the black spaces of the previous field and thus the array of black dots will appear to move either vertically, horizontally, or along 45° lines in any of four directions.

This problem associated with such wobble will be described with reference to Figure 13. Figure 13a schematically illustrates the scan line structure. Since the wobble phase on successive scans of a given field differs by 180° the scanning line structure will display a visible high-frequency modulation of the black space between lines shown as black diamond-shaped artifacts 720. The black artifacts 720 will appear to move in a diagonal manner on the image. This movement may be objectionable to a viewer.

If the spot wobbling frequency is chosen to be an even integer multiple of one-half of the line rate a herring-bone pattern of lines is produced on the display. In this case the interstitial scan lines of one field do overlay the black lines of the previous field, however, not all of the picture elements of a high-definition television raster will be scanned resulting in a lack of full resolution on the display.

Referring to Figure 14a, a wobble pattern is illustrated which is wobbled at an even integer multiple of one-half the horizontal line rate, i.e., $2n\,f_H/2$ to produce the herringbone pattern of lines 1, 2, 3, 4 (line 1 having an arbitrary starting point) to denote, respectively the four field sequence. One field of this pattern is schematically illustrated in Figure 13b. The black portion of the herringbone pattern is completely filled by the next following field thereby eliminating the moving array of black dots of Figure 13a. As illustrated in Figure 14a, however, the beam fails to scan all the pixels of the complete high-definition television raster.

Figure 14b illustrates a wobble pattern similar for both eliminating the artifacts of Figure 13a and scanning all the pixels of the high-definition raster. In Figure 14b, the wobble cycles occur in even integer multiples of one-half the horizontal line rate (i.e., at a rate $2n\,f_H/2$) so that the wobble pattern is in phase on time-successive lines (p, p+1; p+4, p+5 of field 1) in a field and in a frame (p2, p+3; p+6, p+7 of field 2). To achieve dot interlace or full coverage of the high-definition television raster the wobble phase is inverted on alternate frames. A herringbone pattern results from such scanning which is completely filled in during two full frames.

In Figure 14b, the pixels are explored by the high-definition camera of Figure 4 (modified as shown in Figure 15) at a wobble frequency of $4\times f_{sc}$, giving a pixel sampling rate of $8\times f_{sc}$ or $1{,}820\times f_H$ in which f_H is the horizontal line scan frequency and the integer 1,820 is selected to provide a sample frequency of eight times the chroma sub-carrier. The phase of the sampling pattern is inverted on alternate frames. Thus, during the scan of the nth line of a first field (1) of a first frame, the wobble causes exploration of the pixels including, in order, pixels 610, 612, 614, 616, 618 ... It will be noted that the sinuous path described by the raster wobbling at an even integer multiple of one-half the line scanning frequency causes an in-phase condition on scan lines laid down in time sequence, as for example,

the pattern of pixels ⊗ 610, 612, 614 of the nth line is physically the same relative to the pattern of pixels ⊗ 620, 622, 624 during the scan of the next line n+1 of the first field of the first frame. After the end of the first field, a second interlaced field (2) is scanned, followed in due course by the pixels ⊗ 626, 628, 630 of line q which is interlaced between lines n and n+1.

During the first field (3) of the next following (second) frame, pixels X 632, 634, 636, 638 . . . of line n are explored followed by the pixels X (not numbered) of line n+1. In the second field (4) of the second frame, the pixels X (not numbered) of line q positioned correspondingly to the pixels X of line n+1 in the second frame are explored. It will be noted that the second set X of pixels being explored during the second frame constitute a completely different set of pixels ⊗ of the 1,050 line high-definition raster. As described above, in order to provide full resolution of a raster being scanned at an even integer rate in accordance with the present invention, the phase of the wobble signal is inverted in alternate frames. If the wobble signal phase were not inverted pixels 632, 634, 636, 638 of line n would not be explored in alternate frames; instead pixels 610, 612, 614, 616 would be explored in every frame. By inverting the wobble signal phase on alternate frames a full resolution image is achieved when an even integer multiple of one-half the line scan frequency is used.

Referring now to Figure 15, an explanation of the phase reversal will be provided. To achieve the phase reversal of the wobble scan the camera of Figure 4 is modified in that a switch 27 and an inverter 29 are interposed between the wobble signal generator 28 and the auxiliary deflection winding 26. Switch 27 is operated at a rate equal to the frame rate or to one-half of the vertical field rate, $f_v/2$. In this manner the signal derived from generator 28 is coupled to auxiliary deflection winding 26 alternately via inverter 29 and conductor 31. Thus, the phase of the wobble signal is inverted at the frame rate. Illustratively the wobble signal generator 28 of Figure 15 provides a signal of 14.3 MHz (4 fsc).

Figures 13—15 show a manner of generating a high-definition television signal in which the high-definition components include portions attributable to both vertical and horizontal directions. For transmitting and receiving a high-definition television signal over a limited bandwidth channel reference may be made to the description of Figures 10 to 12. That description describes a transmitter for receiving high-definition luminance signals and chrominance and synchronizing signals and for generating a compatible signal for transmission over a limited bandwidth channel. The high-definition components of the still portions of the picture are concealed within the vertical and horizontal blanking intervals. Further, there is described a high-definition television receiver suitable for receiving the high-definition signals transmitted in such a fashion.

Figure 16 illustrates, partially in block diagram form, a high-definition color television generating system that provides a composite wobble scan signal from digital processing of a progressively scanned camera signal wherein the horizontal scanning is performed in a linear manner utilizing a single line store to effect wobbling. Figures 17—19 will be used to explain the operation of the high-definition system of Figure 16. Referring to Figure 17a, a portion of the raster of high-definition television camera 1202 is shown having pixels A1 through A1820 in subraster row or line A, B1 through B1820 in sub-raster row B, etc. High-definition television camera 1202 is operated to scan horizontally at a rate of four times the horizontal line rate of a standard definition camera (i.e., $4f_H$) to scan 1,050 scan lines per field and vertically at a rate equal to that of a standard definition camera (i.e., f_v). The R, G and B signal outputs of camera 1202 are matrixed in matrix 1204 to form Y, I and Q signals in the usual manner. These signals are fed through gate (alternate line pair gate) 1206 which is clocked at a rate equal to one-half of the horizontal scan rate of camera 1202 (i.e., f_H) to pass alternate line pairs, i.e., signals from lines (1, 2) (5, 6) (9, 10) etc. during fields 1, 3 and other odd fields of the continuous four field raster of Figure 17b. In Figure 17b solid lines represent lines transmitted through gate 1206 whereas dashed lines represent lines blocked form transmission. During the vertical scan of field 2 and successive even fields. gate 1206 passes lines 3, 4, 7, 8, 11, 12, etc. of the continuous four field raster of Figure 17b. The I and Q signals are low pass filtered in low pass filters 1208, 1210, respectively, to about one-quarter (illustratively, 8 MHz) of that of the Y signal, illustratively, on the order of 32 MHz. Because of the high speed scanning the R, G and B signals, as well as Y, I and Q signals, have bandwidths of eight times that of a standard definition signal (NTSC) even though existing only 50% of the time. Eight times the standard rate comes from the fact that the horizontal scan rate is four times that of standard definition and the high-definition signal has twice the resolution (high-frequency content) as that of the standard definition signal. Thus, to sample Y, I and Q at the equivalent rate of four times the chroma sub-carrier (i.e., $4f_{sc}$) the sample rate must be at 32 times the chroma sub-carrier (i.e., $32f_{sc}$).

The Y, I and Q signals are converted from analog to digital in analog-to-digital converters 1212, 1214 and 1216. Since the sample rate is at $32f_{sc}$ the analog to digital converters must operate at that rate. To achieve this high speed analog-to-digital converters 1212, 1214 and 1216 may be implemented by using a plurality of analog-to-digital converters for each of the blocks 1212, 1214 and 1216 and multiplexing the data to operate at the high data rate.

Figure 18 is a timing diagram showing samples of signals of the high-definition system of Figure 16. Timing diagrams 18a, 18e and 18i represent

the output of analgo-to-digital converter 1212 wherein two line gaps are created in the timing sequence by gate 1206 which passes alternate line pairs.

Encoding a composite signal at the signal source by digital means is aided by sampling at an integer multiple of the color sub-carrier, e.g., $4f_{sc}$. Referring again to Figure 17a, the phase values indicated at each sub-pixel correspond to wobbling at the $4f_{sc}$ rate and high-definition sampling at $8f_{sc}$. The phase values indicated on Figure 17a of the high-definition television sub-pixels are those values that must be assigned to guarantee compatibility with the standard definition receiver that will filter out the high-frequency components above the standard definition bandwidth (i.e. 4.2 MHz).

To effect the correct phase values the sampled Y, I and Q signals are combined in composite matrix 1218 to form the signals Y+Q, $Y+1/\sqrt{2}$ (I+Q), Y+I, $Y+1/\sqrt{2}$ (I—Q), Y—Q, $Y-1/\sqrt{2}$ (I+Q), Y—I and $Y-1/\sqrt{2}$ (I—Q) representative of samples occurring at 0°, 45°, 90°, ... 315° phase positions of the color sub-carrier f_{sc}, respectively. The matrixed output signals occurring at the rate of $32f_{sc}$ are selected in sequence by selector switch 1220 that steps at the $32f_{sc}$ rate providing two output signals on conductors 1222 and 1224 differing by 180° of sub-carrier phase. These signals consist of samples derived from alternate line pairs, which lines occur at a rate of four times the standard-definition line rate (i.e., $4f_H$), with time gaps during the missing alternate line pairs. Switch 1226 operates at the standard definition horizontal line rate (i.e., f_H) to invert the color sub-carrier on every fourth HDTV line corresponding to alternate lines of standef TV. For example, in Figure 17a the phase of the samples is inverted between lines B and C and between F and G.

Alternate samples are gated by gate 1228 to switch odd samples, i.e., A1, A3, A5, ..., B1, B3, B5, ..., C1, C3, C5, ..., D1, D3, D5, ... to one (odd) output from gate 1228 and even samples A2, A4, A6, ..., B2, B4, B6, ..., C2, C4, C6, ..., D2, D4, D6, ... to the other (even) output of gate 1228. In other words, the signals gated by gate 1228 are delivered to switch 1230 which operates at four times the horizontal rate or equal to the rate that the camera scans in the horizontal direction. Double pole, double throw switch 1232 operates at one-half of the vertical rate (i.e., $f_v/2$). Switch 1232 provides the polarity reversal on alternate frames necessary to effect full resolution.

The output of delay 1231 and conductor 1234 are switched by switch 1236 (illustratively operating at $32f_{sc}$) such that samples are selected alternately from delay 1231 and conductor 1234 to intermingle in a wobble fashion the pixels of the sub-raster lines of Figure 17a in accordance with the wobble described herein.

The operation of gate 1228, switch 1230, switch 1232, delay line 1231 and switch 1236 will be explained with reference to Figures 17—19. In Figure 19, AND gates 1502, 1504 each have one of their inputs 1506, 1508 connected to input conductor 1229. Inputs 1510, 1512 of AND gates 1502, 1504, are coupled via switch 1514 to clock 1516 operating at $32f_{sc}$. Switch 1514 is operated at one-half of the rate of clock 1516 to alternately enable AND gates 1502, 1504. In operation, samples from switch 1226 shown in timing diagram 18a are alternately switched to the outputs of AND gates 1502, 1504 such that odd samples are clocked through to the output of AND gate 1504 for delivery to one input of switch 1232 and even samples are clocked through to the output of AND gate 1502 for delivery to the other input of switch 1232. Thus, with switch 1232 connecting odd samples to delay 1231 in field one of frame one (i.e., switch 1232 thrown to the left) of any scanning sequence odd pixels of odd lines, e.g., A1, A3, etc. are switched via switch 1230, 1232 to delay line 1231 and even pixels of even lines, e.g. B2, B4, etc. are switched via switches 1230, 1232 to conductor 1234. Timing diagram 18b shows the sample sequence going to delay 1231 or conductor 1234. Switch 1236 operates to intermingle the samples from delay 1231 and conductor 1234 such that the even samples are interposed between odd samples as shown in timing diagram 18c.

For the next field, i.e. field two, frame one, odd samples from lines C, G, etc. are switched to delay 1231 and even samples from lines D, H, etc. are switched to conductor 1234 (see timing diagram 18f). Switch 1236 switches such that the even samples, i.e., D2, D4, ..., D1820, etc. are intermingled between the odd samples, i.e., C1, C3, ..., C1819, etc. to create a wobble scan effect as shown in timing diagram 18g.

For the next field which is the first field of frame two switch 1232 is thrown to the right such that even samples are passed through delay 1231 and odd samples are passed to conductor 1234. Thus, even samples from lines A, E, etc. are switched to delay 1231 and odd samples from lines B, F, etc. are switched to conductor 1234 (see timing diagram 18j). Switch 1236 switches the samples such that the even samples, i.e., A2, A4, A6, are intermingled between the odd samples, i.e., B1, B3, B5, ..., B1819 to create the wobble scan effect shown in timing diagram 18k. These alternate samples from adjacent intermingled lines are passed through a first-in-first-out (FIFO) buffer 1238. Buffer 1238 may be a delay line having space to store one line of data (i.e., 1820 samples). The data is clocked into buffer 1238 at a $32f_{sc}$ rate and clocked out at a rate of one-fourth of the input rate or at an $8f_{sc}$ rate. This variation in the rates of clocking data into and out of buffer 1238 removes the gaps that were introduced by gate 1206 wherein alternate line pairs of alternate fields were gated plus the gaps introduced by delay 1231. Timing diagrams 18d, 18h and 18l show the slowed down samples clocked out of FIFO buffer 1238 without gaps. These samples (the output of buffer 1238) represent the composite wobble signal. The digital signal from buffer 1238 is converted to

analog in the digital-to-analog converter 1242, equalized in filter 1242 having a sin x/x impulse response. The filtered signal may be transmitted as an analog high-definition television composite wobble scan signal in accordance with the technique described above with reference to Figures 10 to 12; advantageously, this wobble signal is compatible with standard definition receivers.

To assure that in a high-resolution display, the quality is not marred by scan structure artifacts compounded by spot wobble, a line-scan television monitor 1602 is described with reference to Figure 20. In the monitor of Figure 20 a progressively scanned horizontal line raster 1606 wherein a picture is displayed having full resolution in every display field is provided. In this system each pixel transmitted in the wobble pattern is accumulated in its proper position in random access frame memory 1604 until a complete high-definition television frame (i.e., four NTSC fields) is ready for progressive display. Frame memory 1604 is a 1050-line memory. Associated with frame memory 1604 are WRITE address generator 1608 and READ address generator 1610. This arrangement eliminates sub-pixel flicker by storing a high-definition frame of 1050 lines. The information is stored in its proper position at the rate of the incoming signal by controlling WRITE address generator 1608 with the aid of a signal derived from burst separator 1612 and sync separator 1614. On the read side, a local sync generator 1616 determines the reading rate and controls the deflection generator. The reading rate could in principle be independent of the incoming signal rate and can provide the advantage of progressive (i.e., non-interlaced) scan, but normally the reading rate would be synchronized with the writing rate through delay 1618. Illustratively, the delay is such that at least three fields are written in frame memory 1604 to allow the first two lines of Figure 14b to be filled. Maximum high-definition television picture quality would also be achieved if the high-definition color components were transmitted separately from the luminance, but to achieve full color compatibility with NTSC receivers, the standard definition color must be encoded on a 3.58 MHz sub-carrier, implying composite transmission.

A high resolution television receiver using line stores instead of a frame store is illustrated in Figure 21. The high resolution receiver of Figure 21 is arranged to scan at twice the standard definition horizontal frequency, at 31.5 KHz in the case of NTSC. In the receiver of Figure 21 a high-definition signal in a wobble format is received at terminal 1702. A high-definition kinescope 1704 displays, in a linear manner, the high definition signal received at terminal 1702. In accordance with Figure 21 the display is scanned vertically at the standard definition rate and horizontally at twice the standard definition rate, i.e., $2f_H$. The high-definition signal at terminal 1702 is delivered simultaneously to analog-to-digital converter 1706 and sync separator 1708. Sync separator 1708 coupled to terminal 1702 separates vertical and horizontal synchronizing signals. The horizontal synchronizing signals are applied to a $2f_H$ phase lock loop 1710 for producing a drive signal at twice the standard definition horizontal rate, i.e., $2f_H$. The vertical drive signal from separator 1708 (containing means for effecting wobble scanning in such a manner that lines are laid down in alternate line pairs with space between the pairs to allow for the alternate line pairs in the next field) is applied to vertical deflection winding 1712 associated with kinescope 1704. The twice horizontal drive signal is applied to horizontal deflection winding 1714 at 31.5 KHz. At 31.5 KHz, each scan across the face of kinescope 1714 occurs in $1/2f_H$ time period.

The input signal is in the form of the signal transmitted by the transmitter of Figure 16 wherein the odd samples from one high-definition television line are intermingled with the even samples from an adjacent high-definition television line. FIFO buffers 1716—1722 are used to separate alternate time successive samples which are arranged in one line of a wobble scan signal into two lines of a high-definition line scan. These two lines may be displayed in a line scan format on a high-definition display such as the display of kinescope 1704. Illustratively, buffers 1716—1722 are 910 sample first-in-first-out rubber buffers. The operation of the system is as follows. Analog-to-digital converter 1706 samples the incoming signal at the high-definition rate, i.e., $8f_{sc}$, which is the rate at which the samples are transmitted by the transmitter of Figure 16. Switch 1724 switches at one-half of the standard definition line rate, i.e., $f_{H/2}$, to load alternate incoming horizontal lines into buffers 1716, 1718 and buffers 1720, 1722, respectively. Switch 1726 switches at a four times sub-carrier rate, $4f_{sc}$, to switch alternate time successive samples into buffers 1716, 1718, respectively. For example, referring to Figure 17a, when the first line of field one, frame one of a high-definition signal is received the odd samples of line A, e.g., A1, A3, A5, etc. are switched into buffer 1716 while the even samples of line B, e.g., B2, B4, B6, etc. are switched into buffer 1718. When buffers 1716, 1718 are filled the signal is switched out of buffer 1716 to write, in the example given, the odd samples of the A line. The next line, i.e., B line, is written from buffer 1718 after buffer 1716 is emptied. While buffers 1716 and 1718 are being read out the signal from the next line is stored in buffer 1720, 1722, respectively, via switches 1724 and 1728. For this example, referring to Figure 17a, the second line of field one, frame one contains the odd samples from line E and the even samples from line F. Switch 1728, like switch 1726, operates at four times the sub-carrier, $4f_{sc}$, to switch the alternate time successive samples into buffers 1720, 1722, respectively.

On the read side, the signal from buffers 1716, 1718 are transmitted via switch 1730 operating at the horizontal rate, f_H, and switch 1732 operating at one-half of the horizontal rate, $f_{H/2}$, to digital-to-analog converter 1734, operating at $8f_{sc}$, wherein the signals are converted to analog form for display on kinescope 1704. The analog signal from digital-to-analog converter 1734 is processed in video processing unit 1736 and applied to kinescope driver 1738 for display on kinescope 1704 at twice the standard definition horizontal rate. Switch 1740 operates in a manner similar to switch 1730 to gate alternate lines of a high-definition signal via elements 1732, 1734, 1736, 1738 for display on kinescope 1704. Switch 1732 is switched out-of-phase with switch 1724 so that during the time period in which lines are being written into one pair of buffers the signal may be read out of the other pair of buffers. For example with respect to frame 1, field 1 of the earlier example line E and F are written into buffers 1720 and 1722 while lines A and B of frame 1, field 1 are being read out of buffers 1716 and 1718. In the next sequence the signals are read out of buffers 1720 and 1722 while buffers 1716 and 1718 are being filled. Figure 21 illustrates a line scan display system for displaying a high-definition video signal which has been transmitted in wobble fashion. In accordance with this system a high-definition display may be implemented with four line buffers of 910 samples each or two line buffers of 1810 samples each. It should be noted that it takes four fields in the system of Figure 21 to display a complete high-definition television image.

Various modifications will be apparent to those skilled in the art. It will be obvious that analog equivalents of functions described in digital terms may be used. Progressive or interlaced scanning may be used or digital equivalence of functions described in analog embodiments may be used.

Claims

1. A television system comprising means for producing signals representing an image and means for reproducing the image from the signals, wherein the signal producing means comprises a source of first signals representing successive scanning paths extending in the line scan direction through the image, the image being represented by the first signals with a first definition; means for processing the first signals to produce second signals representing the image with a second lower definition in the line scan direction, means coupled to the source and processing means to produce signals representing the difference between corresponding portions of the first and second signals, and wherein the reproducing means comprises means arranged to receive and sum the difference and second signals to reproduce the first signals.

2. Means, for use in a system according to claim 1, for producing a signal representing an image, and wherein it comprises a source of first signals representing successive scanning paths extending in the line scan direction through the image, the image being represented by the first signals with a first definition; means for processing the first signals to produce second signals representing the image with a second lower definition in the line scan direction, means coupled to the source and processing means to produce signals representing the difference between corresponding portions of the first and second signals.

3. A system according to claim 1 or signal producing means according to claim 2, wherein the processing means operates so that the second signals represent the image with lower definition than the first signals in the field direction as well as in the line scan direction.

4. A system according to claim 1 or 3 or signal processing means according to claim 2 or 3, wherein the source comprises means for selecting pixels alternately from adjacent scanning lines through the image to produce the first signals.

5. A system or signal processing means according to claim 4, wherein the selecting means comprises a frame store for storing pixels along successive scanning lines through the image, and reading means for reading from the frame store pixels derived alternately from adjacent scanning lines to produce the first signals.

6. A system according to claim 1, 3, 4 or 5 or signal processing means according to claim 2, 3, 4 or 5 wherein the source comprises a camera having means for scanning an image according to a scanning pattern comprising scanning paths distributed in a field scan direction, and means for causing the scanning paths to alternately intersect adjacent scanning lines through the image thereby to select pixels alternately from the adjacent lines to produce the first signals.

7. A system or signal processing means according to claim 4, 5 or 6, wherein the selected pixels are selected from each line at a rate which is an odd multiple of half the line scan frequency.

8. A system or signal processing means according to claim 4, 5 or 6, wherein the scanning lines are lines of a predetermined scanning pattern comprising two interlaced fields of lines forming a frame and wherein the selected pixels are selected from each line at a rate which is an even multiple of half the line scan frequency, the phase of selection being inverted on alternate frames, to produce the first signals.

9. A system according to any one of claims 1 and 3 to 8 or signal processing means according to any one of claims 2 to 8, wherein the processing means comprises means arranged to receive and add the difference signals to the second signals, storage means for storing the sum of the difference and second signals and comparing means for comparing the summed signals from the storage means with the first signals to produce the difference signals.

10. A system or signal processing means according to claim 9, wherein it comprises analogue to digital converter means for

converting the first and second signals to digital form, the storage means and comparing means being digital means, and digital address generating means arranged to produce addresses indicative of the position in the image to which the difference signals relate and for correspondingly writing the difference signals into and reading them out of the digital storage means.

11. A system according to any one of claims 1 and 3 to 10 or signal processing means according to any one of claims 2 to 10, wherein the scanning lines are lines of a predetermined scanning pattern comprising frames and wherein it further comprises means for producing signal indicative of motion within the image between successive frames, and means responsive to the indicative signal for inhibiting the outputting of the difference signals when there is motion in the image.

12. A system or signal processing means according to claim 11, wherein the motion detecting means is responsive to the second signals to produce the motion indicative signal.

13. A system according to any one of claims 1 and 3 to 12 or signal producing means according to any one of claims 2 to 12, wherein the second signals comprise active portions containing information representing the image and inactive portions, and there are means for inserting the difference signals into the inactive portions.

14. A receiver for use in a system according to claim 1, wherein it comprises means arranged to receive and sum the difference and second signals to reproduce the first signals.

15. A system according to claim 9 or a receiver according to claim 14, wherein the receiver comprises adding means arranged to receive and add the second and difference signals, and storage means for storing the added second and difference signals.

16. A system according to claim 10 or a receiver according to claim 15, wherein the receiver comprises digital adding means arranged to receive and add the second and difference signals in digital form, a digital storage means for storing the added second and difference signals, an address generator for addressing the store, to store the added second and difference signals at locations defined by the address generator, buffer storage means for storing the difference signals and digital addresses associated therewith for indicating the position in the image to which the difference signals relate, and address comparison means for applying each difference signal to the adder when its address has a predetermined relationship to an address generated by the address generator.

17. A television system comprising means for producing signals representing an image and means for reproducing the image from the signals, wherein the signal producing means (Figure 16) comprises a source of first signals representing successive line scans through an image the line scans being distributed over the image in a field direction, and means for alternately selecting alternate pixels from adjacent pairs of lines, the pixels being selected from each line at a rate which is an even multiple of one half the line scan frequency, the phase of selection being inverted at half the field repetition rate to produce the signals representing the image.

18. A means for producing signals representing an image wherein the signal producing means (Figure 16) comprises a source of first signals representing successive line scans through an image the line scans being distributed over the image in a field direction, and means for alternately selecting alternate pixels from adjacent pairs of lines, the pixels being selected from each line at a rate which is an even multiple of one half the line scan frequency, the phase of selection being inverted at half the field repetition rate to produce the signals representing the image.

19. A system according to claim 17, or signal producing means of claim 18, wherein the selecting means comprises first gating means for gating the first signals associated with alternate pairs of line scans, matrixing means for switching said first signals, said matrixing means providing second and third signals representative respectively of first and second phases of said first signals respectively; switching means for alternately switching between said second and third signals at a fraction of the line scan frequency; second gating means for gating alternate samples of signals alternately switched by said switching means; and interleaving means for interleaving first alternate samples of signals gated by said second gating means from a first scan line with second alternate samples of signals gated by said gating means from a second scan line.

20. Means for reproducing signals from signals in which signal samples of representing an image along a scan line are interleaved with signal samples along an adjacent scan line, or a system according to claim 19, wherein the reproducing means comprises first and second storage means, first switching means for switching the signal samples alternately to the first and second storage means, and second switching means for alternately passing to an output the samples from one of the storage means and associated with a scan line, and the samples from the other of the storage means and associated with an adjacent scan line.

21. A television system substantially as hereinbefore described with reference to Figure 10 optionally together with Figures 1 to 6b, and/or Figure 11a and/or Figures 11a to 110, and/or Figure 12.

22. A television system substantially as hereinbefore described with reference to Figure 10 optionally together with Figure 15 or with Figures 16 to 19 and/or with Figure 20 or 21.

23. Means for producing signals representing an image substantially as hereinbefore described

with reference to Figure 15 or to Figures 16 to 19.

24. Means for reproducing an image substantially as hereinbefore described with reference to Figure 20 or 21.

25. Means for reproducing an image substantially as hereinbefore described with reference to Figure 12.

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